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THE DEVELOPMENT OF THE AMERICAN COTTON INDUSTRY.

BY FRANK HART.

It affords me great pleasure to address you to-night on the influence of machinery upon the culture, handling and manufacture of cotton in the United States.

India seems to have been the birthplace of cotton culture and manufacture, as of so much else for which we are indebted to that ancient civilization. For 3,000 years, or until the seventeenth century, it was the cotton-weaving center of the world.

While the industry was nowhere else so highly developed at so early a period, cotton was in prehistoric times grown and spun in many parts of the world. The Egyptians were, probably, familiar with it. At the time of Columbus' dis-

covery the fiber was grown and made into cloth by the inhabitants of the West Indies, Mexico, Peru and Brazil. Cotton cloth has been found in the ancient tombs of the Peruvians. Mexico, under the Montezumas, knew neither wool nor silk, and, although it possessed the plant, did not use flax. It is estimated that prior to the Conquest 116,000,000 pounds of cotton were grown annually by the Aztecs, more than four times as much as is produced by their successors in Mexico to-day. Singularly enough, the only region in the Western Hemisphere between the parallels 40° north and 40° south that did not grow cotton prior to the discovery of America is that occupied by the Cotton States, which now produce three-quarters of the world's entire yield.

Herein is seen the influence of machinery, that worker of miracles, which has transformed the face of the earth, annihilated space and time, and made the forces of nature to do the work of man.

It may be true that without machinery cotton would ultimately have been an important article of our Southern agriculture, but it cannot be doubted that, except for this factor, the history of the staple in this country would have been far other than it is, and that instead of enjoying a virtual monopoly of the cultivation of cotton, the South would have borne but an insignificant part in its production.

The first of the colonies to plant cotton was Virginia, in 1621. It was not until 1747 that any cotton was exported, and then only a few bags valued at less than $20. In 1770 three bales were shipped to Liverpool from New York; ten bales from Charleston; four from Virginia and Maryland, and three barrels from North Carolina. In 1786 900 pounds of cotton were exported to Liverpool. The next year the exports to England aggregated 16,350 pounds. In 1790 only 2,000,000 pounds of cotton were grown in the South. The following year 189,500 pounds of American cotton were shipped to Liverpool, the price paid on this side averaging 26 cents per pound.

The foregoing figures represent the growth of cotton culture in the Colonies in 170 years. He would have been set down as a visionary who should have foretold what the next

century, under the impulse of a mighty force harnessed by the genius of man, was to bring forth.

The inventions of that galaxy of mechanicians—Hargreaves, Arkwright, Crompton, Cartwright and Watt—ushered in one of the mightiest of modern industries, and created a demand for more cotton than the world produced. If the South could not be freed from dependence on the devices then in use, it was not to be expected that the increase would be supplied by the United States. To have grown the cotton would have been easy; the difficulty lay in its preparation for market. The lint had to be separated from the seed by hand, a slow and expensive process, which even at the high prices that then prevailed left little return for the cotton farmer, and restricted the growth of the staple in the South practically to the requirements for domestic use.

Whitney's invention of the cotton gin in 1793 made possible the production of cotton in America as a commercial crop. The effect on the South was magical. In 1796, a year after Whitney had improved his machine, the yield had risen to 10,000,000 pounds. In 1800–01 the South produced 48,000,000 pounds of cotton, or 96,000 bales of 500 pounds net. Production grew by leaps and bounds. In 1806–07 it was 160,000 bales; in 1816–17, 260,000 bales; in 1840–41, 1,288,000 bales. By 1859–60 the crop had grown to 4,482,000 bales of 500 pounds net.

Cotton was indeed king! Its production had become the most important agricultural pursuit in America; its producers the wealthiest farmers the world had ever seen. The Civil War paralyzed the industry, but after the return of peace the yield grew steadily, until in 1897–98 it reached 11,216,000, and the year following 11,256,000 gross bales.

As the purpose of this paper is not to set forth in detail the history of the culture, handling and manufacture of cotton in this country, but merely to point out what has been accomplished by the aid of machinery and to indicate what yet remains to be done, in discussing the third phase of the subject, which, for convenience, will be treated before the second, I shall do no more than refer to the growth of cotton spindles in America. The pioneer of an industry which

has contributed enormously to the wealth of New England and the Middle States, and is just now quickening the South to stupendous activity, was a cotton mill erected at Beverly, Mass., in 1788. It was soon followed by others in New England, New York, New Jersey, Pennsylvania, and at Statesburg, in South Carolina.

Although possessing the strategic advantages of cheap labor, abundant water power and proximity to the cotton fields, the South neglected until after the Civil War to avail herself of them. For three-quarters of a century she was content to supply the raw material whose fabrication enriched the North, England and Continental Europe. The past two decades, however, have witnessed an industrial revolution in the South. This favored region has become an important, and promises at no distant period to be the dominant, factor in the cotton manufacturing situation. Last year, it is estimated, mills were built or begun in the South, requiring in the aggregate 1,824,000 spindles and 23,300 looms, and involving an investment of $33,714,000. Mr. D. A. Tompkins, the cotton mill expert of Charlotte, N. C., estimates that 2,000,000 spindles will be installed in Southern mills this year.

To quote this authority: "There are now 5,000,000 spindles in the South, 13,000,000 in New England and 2,000,000 in other States. England has 46,000,000 spindles. If the present rate of increase, 2,000,000 a year, continues, in ten years the United States will have 45,000,000 spindles, of which the South will have 25,000,000—more than New England and the Middle States combined."

Not the least of the South's debt to machinery is owed to the invention of processes for the utilization of the cotton plant's by-products. Although the value of cotton-seed oil was known in the last century, it was not until about 1850 that it was produced as an article of commerce. In 1867 there were only four oil mills in the South. Now there are several hundred. In an average season they crush 1,500,000 or 2,000,000 tons of seed, which yield cotton-seed oil and other products having a value of some $30,000,000. Probably not more than 40 per cent. of the available cotton seed reaches

the oil mills. When all of the crop, except the requirements for reseeding, finds its way there to be converted into oil, cattle feed and fertilizer, the South will receive a revenue of some $60,000,000 or $70,000,000 annually from a by-product, of which, in ante-bellum days, almost no use was made.

Unfortunately, the handling of cotton has not kept pace with its production. Save the roller gins employed for delinting Sea Island cotton, the gins used now, while vastly improved mechanically and of greatly increased outturn, are in principle the same as that invented by Whitney. They are made up of gangs of seventy or eighty circular saws, working between ribs, the teeth of which tear the lint from the seed and greatly injure the fiber. In old-style gin-houses the lint, as it leaves the condenser, is thrown into the gin press, by which some 500 pounds of cotton are pressed into a rectangular bale weighing about 12 pounds per cubic foot. This bale is partly covered with coarse jute and rudely bound with six or more iron bands, which, with the bagging, weigh some 22 pounds.

From the moment it leaves the gin-house the square bale's troubles begin. It is taken first to the local cotton market, where it is freely sampled by country buyers. Thence it is delivered to the railroad to be conveyed to the nearest compress. Inasmuch as a quarter of the Southern cotton crop annually moves to the local freight stations in thirty days and three-quarters in four months, the railroads are utterly unable to handle the traffic. Blockades result. The cotton lies uncovered on the local depot platforms or on the bare ground, often as long as six or eight weeks, exposed to the elements. Arrived at the compress it awaits its turn to be compressed. The result of this treatment is "country damage," claims for which at the single port of Liverpool aggregate $500,000 a year.

In the compress the gin-bale is subjected to a pressure of from 2,400 to 3,000 tons and reduced to about half its former thickness, or to a density of some 22 pounds per cubic foot. The ties are shortened and the side pieces, if any were put on at the gin, are taken off. The compressing, which costs 50 cents a bale, occupies but a few seconds,

and resembles a blow from a ponderous steam hammer. Along with the cotton much air is compressed in the bale, which by supporting combustion in the interior, where the fire cannot be reached, makes of the square bale of cotton a veritable fire-trap. The jute bagging, with which a pretense is made of covering the bale, affords almost no protection to the lint. Loosely woven, it readily permits the absorption of moisture. More inflammable even than the cotton itself, it invites rather than prevents fire.

It was inevitable that this crude system would be superseded by a better. Indeed, the wonder is that the square bale abuses should have been tolerated so long. It was early recognized that the root of the evil was the bale itself, and that any improvement, to be of value, must begin with a better bale. It was seen, too, that the cotton bale of the future would be cylindrical in shape. The first attempts at forming a round bale were made more than 50 years ago. A machine for rolling up cotton in the shape of a cylinder was patented by North in 1848, but nothing came of it. Many subsequent attempts were made with equal want of success. The chief obstacle lay in devising a machine that would put up cotton under pressure in a bale perfectly round; otherwise it was impossible to secure sufficient density. The greater the pressure applied to a bale of uneven formation, the more out of round it became, and it soon stopped revolving altogether or resulted in a comparatively soft bale. The next difficulty was in so regulating the pressure as to prevent hard centers.

For many years mechanical minds labored to solve these problems. The American Cotton Company's roundlap press is the sum of their combined efforts. It is covered by more than fifty patents and represents the expenditure of vast sums of money. The press has two horizontal rolls, and a hydraulic cylinder connected with a large air chamber regulates the pressure automatically.

To insure uninterrupted operation the press is now built in duplicate. Attached directly to the gins, it takes up and bales, without stopping for the removal of finished bales, the entire output of from three to eight 70- or 80-saw gins.

On its way from the gins to the press the lint passes through a lint flue equipped with dirt pockets by means of which all sand and dirt are removed. From the lint flue it passes over a condenser having a velocity of about 50 revolutions per minute. The cotton, barely touching the condenser drum, is thrown off, the air and dust pass through the wire cloth above, while the cotton, a fluffy mass some 5 feet thick, passes on over and falls into the bat-former—comprised of two converging aprons, whose adjacent surfaces travel in the same direction—which delivers it to the compression rolls in a uniform bat 10 or 12 inches thick and weighing 2¾ pounds to the yard. This bat moves at the same speed as the press. Thus a continuous lap of cotton is made that unrolls as easily as it is rolled up. As it passes beneath the compression roller the air is excluded and the compressed cotton is wound around a core under a pressure, which, light at first, is gradually increased automatically until the bale attains its full size. In this way, by the steady exertion of an even pressure of less than 15 tons gradually applied to all the cotton in detail, a bale is produced having a density of 35 pounds per cubic foot, as against the density of 22 pounds attained by the square bale after a second compression in which a force 200 times greater is employed in one ponderous blow directed against all the cotton in mass.

By reason of this moderate pressure, gradually applied as the bat moves forward under the roll, one end of every strand of cotton is in effect fixed while the pressure of the expelled air straightens out the fiber and it is caught and held in that position. This action and the pressure are not so great as in any way to affect the natural spirality of the cotton fiber so important to the spinner or to injure the fiber in the smallest degree. The air having been pressed out, the bale, besides being rendered practically indestructible by fire, is self-containing, has no tendency to expand and does not require iron ties. When the bale is of proper size it is completely covered with a light, closely woven, inexpensive burlap, which keeps the cotton clean and dry. Weighed, marked and tagged, the bale is ready without

further compression for through shipment to the mills in America or to ports abroad. Formerly bales were made 48 inches in length and 25 inches in diameter. Thirty-five inches having been found a length more suitable for handling at the mills, the presses are built to turn out bales of that length, 22 inches in diameter and weighing 270 pounds each.

While the bale is being made, an uncompressed sample 10 x 24 inches and about 4 inches thick is drawn and divided into two pieces, each about 10 x 12 x 4 inches. These are tagged to correspond to the tag number of the bale, one is sent to the American Cotton Company and the other is retained by the ginner or delivered to the owner of the cotton. On samples taken in this way the American Cotton Company has bought hundreds of thousands of roundlap bales, which it has in turn without further sampling sold, with fewer disagreements and reclamations than would have accompanied a square bale business of equal magnitude. While sampling is entirely unnecessary, if for any reason it is desirable, a roundlap bale can be resampled as readily as a square bale.

In furtherance of its purpose to insure to the South that the economies of its baling process shall be reaped in full, the American Cotton Company has organized a system for the through handling of cotton from gin-house to mill. In order to insure a ready market for all cotton baled on its presses, the Company became a cotton buyer to the extent of agreeing to buy any and all cotton properly put up in roundlap bales, and to pay therefor 45 cents per hundred pounds more than the market price of the same cotton in old-style bales. This premium is the first fruit of the roundlap bale economies, and it is paid to the planter.

It is impossible within the limits of this paper to do more than allude to the savings effected by the roundlap bale. The elimination of the necessity of a second compression, although the keystone of the roundlap system, is only one of many economies. As against bagging and ties for a 500-pound square bale, which, as has been said, weigh 22 pounds, and cost 75 cents, the covering for an equivalent of

cotton in roundlap bales weighs 5 pounds and costs 25 cents. Besides this initial saving of 50 cents per bale in the cost of covering, there is a further saving of freight on the 17 pounds excess weight of bagging and ties. Colonel A. B. Shepperson, the eminent cotton statistician, in considering this phase of the cotton handling question, in the latest edition of his "Cotton Facts," points out that, owing to this excess weight of bagging and ties, in the marketing of the 1897–98 and the 1898–99 cotton crops freight was paid on the equivalent of over 800,000 old-style bales more than would have been required to market those crops in roundlap bales. Estimating that the cost of transporting cotton to the mills averages $6.25 a bale, which is believed to be well within the actual figures, the freight charge against these two crops, arising from the excess weight of bagging and ties, was $5,000,000 more than it would have been had the Southern staple been marketed in roundlap bales. This does not take into consideration the freight originally paid in sending the surplus weight of bagging and ties to the cotton plantations, which was not less than $2,000,000 for the two crop years in question. Thus in two seasons the South paid $7,000,000 in needless freights on the surplus weight of the materials used to cover its cotton—materials, moreover, which not only do not protect the staple from damage, but fail to preserve intact the package they are employed to make.

This loss is small beside that involved in the transportation of the old-style bales themselves. Uncompressed square bales, loading to one-fourth, and compressed square bales, to one-half the weight capacity of cars, pay rates based on full carrying capacity. Roundlap bales, on the other hand, load to the full weight capacity of freight cars. Shipments of the American Cotton Company's bales weighing 68,628 pounds and 72,226 pounds, respectively, have been made in a single car. Roundlap bales being shipped from gin-plants through to the mills in this country or to cotton ports abroad, the employment of rolling stock in the profitless traffic of concentrating cotton for compression is obviated. Competent railroad authorities estimate that

roundlap cotton can be handled with one-fifth the number of cars required to market the equivalent of square cotton. On shipboard roundlap bales stow with a saving of one-third the space occupied by square bales, with greater ease of handling and without needing to be screwed in. If the average freight charge for carrying Southern cotton to the spindles of the world is $6.25 per 500-pound bale, the marketing of a 10,000,000-bale crop involves an expenditure of $62,500,000 for freight. That roundlap bales can be carried by railways and steamships at a saving of one-third the cost of transporting square bales is an estimate that leans to the side of conservatism. If this be true, it follows that when the adoption of the roundlap baling system becomes general throughout the South $20,000,000 will be saved annually in the expense of transportation.

It is estimated that raw cotton pays every year some $4,000,000 for marine and fire insurance, Of this, $500,000 goes to pay the "country damage" claims on square cotton received at the single port of Liverpool. At least half as much more is required to pay "country damage" claims arising elsewhere. Here is three-quarters of a million dollars that can be saved annually by the roundlap bale, against which there has never been a claim for "country damage," to say nothing of the large saving in marine and fire insurance premiums due to the roundlap bale's superiority as an insurance risk.

The petty leaks, small as they seem in themselves, grow in the marketing of a season's crop into stupendous losses. From the gin to the mill square bales change ownership from three to five times, and are as often reweighed, re-examined and reinsured. Every time a bale is sold, and frequently when it isn't, it is sampled. Between sampling and theft, the square bale loses first and last some 5 pounds of lint, which, baled, go to make up the "city crop." This crop is wholly independent of climatic conditions and never fails. It is estimated by a well-known statistician to yield annually 100,000 500-pound bales, worth to the farmer, at 7 cents a pound, $3,500,000. Hon. I. F. Culver, Commissioner of Agriculture of Alabama, in a paper read before the

Cotton States Association of Commissioners of Agriculture, in Atlanta, Ga., in October last, estimated the expense of reweighing, re-examining and reclassing square cotton, exclusive of the lint lost, at 30 cents a bale, or $3,000,000 annually. Mending square bales costs not less than 10 cents a bale, or $1,000,000 for an average crop.

Square bales are sold abroad less 6 per cent. tare. The covering for the American Cotton Company's bales weighs 5 pounds for each 495 pounds of lint. When cotton thus packed reaches the ports abroad, clean and uninjured, it weighs exactly what it weighed at the gin, the covering weighs no more and no less than when it was put on, and the bales are sold less 1 per cent. tare, a saving of 5 per cent.

The saving at the mills begins with the unloading of the cars. The most approved method of handling roundlap bales is to place three or four bales directly on the apron of the breaker lapper, from which they unroll automatically directly into the machine. There are, besides the material saving of expense, further savings of wastage and loss of weight. A comparative test of roundlap and square cotton was made in the Massachusetts Cotton Mills, of Lowell, Mass., last month, to determine the relative shrinkage in weight by drying out. The cotton was opened, loosened by hand, placed in new bags and allowed to stand 184 hours before being reweighed. The square cotton showed a loss of 2·283 per cent., the roundlap cotton a loss of 1·271 per cent. The saving in favor of roundlap cotton was 1·012 per cent., or 4·837 pounds per bale of 478 pounds net. It is impossible to express in terms of money these economies at the mill, but a mill owner, whom an experience of several years in the use of roundlap cotton has enabled to give the subject careful consideration, estimates them at not less than one-eighth of a cent per pound.

According to the foregoing estimates, all of which are believed to be conservative, the savings which would accrue from the marketing of a 10,000,000-bale crop in roundlap bales may be summarized as follows:

On bagging and ties	$5,000,000
Compressing 80 per cent. of square bales	4,000,000
Freight	20,000,000
Screwing in and labor saved at ship's side	1,250,000
Unnecessary sampling and theft	3,500,000
Insurance (including country damage)	1,500,000
Reweighings and yardage	3,000,000
Mending	1,000,000
At the mill	5,500,000
Total	$44,750,000

This enormous sum is the annual tax imposed on the cotton States by an unscientific system. It means that $4.50 of the proceeds of every square bale of cotton is wasted. The roundlap bale saves all this waste. Its economies accrue not alone to the profit of the producers of cotton, the common carriers, the makers and operators of roundlap baling presses and the users of roundlap bales, but they may be shared also by responsible cotton buyers, merchants and bankers and by every other legitimate commercial interest engaged in the marketing of this great staple.

Mechanical and Engineering Section.

Stated Meeting, held February 8, 1900.

FIRE HAZARDS.

By H. de B. Parsons, M.E.

"An ounce of prevention is worth a pound of cure" is an old adage containing much that is worth practicing. The ratio in the phrase is one in sixteen, but are there many who put, out of sixteen chances, one on the side of safety? With fire risks, it would seem truer to place the ratio at one in a hundred and alter the phrase to suit—a cent of prevention is worth a dollar of cure. Even that proportion of the cost of a building is rarely spent to reduce the fire hazard. Nearly every one figures on a loss by fire as one of money

alone, which may be covered by insurance. Unfortunately, fires cause losses that are not so protectible, such as loss of life, of treasures, of archives and of time, none of which can be replaced.

Many owners of buildings spend large sums in fire apparatus, extinguishers and the like. The same amount of money and energy spent on original construction and design would have been more effective. The author is fully aware of the value of these agents, and does not desire to belittle them. While the original weakness still exists they can only act by lessening the extent of the hazard, or, in other words, their successful application depends on something other than the building itself.

The value of a building depends upon its income-earning capacity, and it is a well-established fact that safe buildings command little, if any, additional rent over those in which such qualities are but veneer. Tenants are guided chiefly by modern conveniences and showy appearances.

The total amount of risks in force in the United States by United States fire insurance companies and by branches of foreign companies on December 31, 1898, amounted to $36,984,810,997. The average premium was about 90 cents on each $100 of risk. The fire losses paid during that year were $71,785,247.

If more forethought were given to the details of design and construction, a large sum would be saved annually in insurance premiums. To illustrate, the owners of a certain building told their architects to produce a structure that would be classified at the lowest rate of insurance for the business intended. Owing to neglect of proper column protection, this building was annually charged an excess of premium of $3,000, or the interest at 6 per cent. on $50,000. The columns could have been protected for less than this figure, and as the building could have been mortgaged for 4 per cent. or less, the saving would have exceeded $1,000 per annum.

Many imagine because iron and steel are incombustible (in the ordinary sense of the word), that buildings constructed of such materials, together with glass, bricks, and cement, can always be classified as fire-proof. Such build-

ings may be proof against an internal fire when empty, but, unfortunately, full consideration is not always given to the effect of inflammable contents, or of the hazard caused by a neighboring structure.

The design of a really fire-proof building is more difficult of execution than generally imagined. The term "fire-proof" has become generic, and is, in many instances, a misnomer. In its broad sense, it is used to classify a certain style of modern construction that has become very popular, as is attested by the wonderful and rapid growth of such buildings in our cities.

It is impossible to conceive of a building that could not be damaged by fire. The more fire-proof a building is made, the greater will be its cost and the less its utility for modern demands. The problem is economic, and must be settled by balancing the questions involved.

A fire-proof structure may, then, be defined as one that will be damaged by fire to a minimum extent, while considering the hazards from within as well as from without; one in which the injury will be localized, and one in which the main-supporting or weight-carrying members will not be injured to an extent that will render them useless.

The ordinary method of construction, with brick and stone walls, wooden beams and floors, is in no sense fire-proof, and the hazard is great, depending on its use, exposure and class of tenant.

The destruction of the Burdette Block, in Troy, N. Y., on February 17, 1896, cost four lives, and was caused by the careless dropping of a match. The fire took place while the thermometer was at zero or just below, and the ice formed in the streets as high as the tops of the basement store windows and completely covered the whole front, making a most beautiful spectacle under the bright sun of the day following. The building was of the ordinary wooden beam and floor construction, and was consumed with fearful rapidity.

While buildings of this construction cannot be designed as fire-proof, still much can be done to render them slow-

burning by proper division with fire-proof walls made self-sustaining.

The Washburn & Moen Manufacturing Company's Quinisigamon Works, Worcester, Mass., were destroyed by fire on April 5, 1899. This building was built on the "cage" type of construction, consisting of a steel frame supporting the floors and roof, with enclosing walls of brick built in between the posts. The posts and beams were of steel, spaced 8 feet on centers. The window frames were of steel, and the only wood employed was in the floors and roof. The building was used for the manufacture of steel springs, and the floors were not heavily loaded. The fire spread with extreme rapidity, partially due to the vapors of oil which had condensed on the ceilings.

The general lesson of this fire was the inability of steel and iron to withstand heat, and the futility of attempting to build an iron or steel fire-proof structure unless the metal be thoroughly protected. Had concrete floors been used in place of wood, of course much of the combustible material would have been removed from this particular building, but the risk would have been great had the contents been combustible, or had it been exposed to an adjacent hot fire.

Witnesses of this fire stated that the columns and beams began to yield by bending within from fifteen to twenty-five minutes after the fire started. Nothing could have been more complete in the line of destruction.

The temperature of this fire can only be inferred from the effects. A cast-iron cone pulley was found which showed evidence of having been heated to a plastic condition, and a portion of a cast-iron cylinder of having been melted. Cast iron melts at about 2,000° Fahr.

Various tests have been made on unprotected metal columns which have shown failures similar to those in actual buildings.

The following table gives the data of fire tests on unprotected columns made by the Committee on Fire-Proofing Tests in 1896:

Test.	Weight of Column.	Conditions.	Temperature.	Load, Tons.	Time.
1	823 lbs. steel	Slow heat	1,200°	46·0	1 hr. 21 m.
2	690 " "	Rapid "	1,175°	84·8	0 " 23 "
3	928 " C. I.	Slow "	1,100°	84·8	1 " 8 "
4	928 " "	Rapid "	1,350°	84·8	0 " 35 "
5	928 " "	Slow "	1,200°	84·8	2 " 15 "

Each column was designed to carry about 85 tons as a full safe working load. In each case, the time mentioned is given from the moment the fire started until the column began to yield by bending.

Test No. 4 was suddenly terminated by the fracture of the column without warning.

Test No. 5 was prolonged by repeatedly cooling the column with water.

None of the columns began to yield until they showed "red," so that it may be inferred that they would have continued to carry their loads had they been protected, or had the loads been less than their safe capacity.

For buildings intended for manufacturing and for certain kinds of mercantile business, a form of design known as the "Slow Burning" or "Mill" construction is to be preferred to any form of iron or steel construction with unprotected members. This construction makes use of timber for posts and girders, over which is laid a flooring sufficiently thick as not to require joists. The best forms use double floorings with tin, salamander or some other fire retardent between them. The posts and girders should be of such scantling as to permit encroachment by fire to a depth of about 2 inches without impairment of strength for their respective loads, as it has been found to require a long period before fire will char a heavy timber to a greater extent. Great care should be exercised to see that there are no air spaces left in the construction.

Modern mills are made too wide to permit the beams to span from wall to wall, as was the practice in older forms. Posts, therefore, must be adopted. No matter what material is used, the design should contemplate fire resisting and fire retarding. This latter can be accomplished by use of fire

walls, self-sustaining, so placed as to separate or cut the building into sections. Access can be provided by openings closed with fire doors, the best form of which is probably that known as the "Underwriters" type. These walls should extend through the roof about 3½ feet, and project out through the sides of the building about 2 feet when there is danger of the fire spreading through windows.

The chief hazard, other things being equal, is the danger caused by draft up the hatchways and stairs. This hazard can be remedied by making such openings in a separate, tower-like building into which connection can be made by bridges at the different floor levels. When the ground plan will not permit of this arrangement, the hatchways and stairs can be placed in a narrow section, separated off by fire walls on each side, with the openings into the main parts of the buildings located so as not to be opposite, and equipped with double fire doors.

In no form of construction should heavy weights, such as tanks, be supported on or suspended from the tops of buildings, unless such weights be carried on some permanent form of fire-proof construction fully protected.

As an example of this defect may be mentioned the Windsor Hotel, in New York, which was destroyed by fire on the 17th of March, 1899. This fire took place during the daytime, when every advantage was afforded the fire department, with the exception of a prompt alarm.

This building was of the ordinary brick construction, in plan like a flat U, 200 feet long, 180 feet deep and eight stories high, having a light court in the rear; and classified by firemen as a "quick burner" owing to the wide corridors on each floor and lack of fire division walls. There was a large water tank on the roof at the center of the front, said to contain about 100,000 gallons; and it has also been stated that, owing to some change in original plans or in lack of foundation support, part of the building was suspended from girders across the top of the building.

The fire is supposed to have started about fifteen minutes before the alarm was given. It originated in the basement and extended throughout the structure with fearful rapidity.

The fire enveloped the center of the building, passing up the elevator shafts and court, and spread to each floor of the Forty-sixth Street or south wing, working its way towards Forty-seventh Street through the corridors on each floor. The front wall under the tank began to fall about thirty-five minutes after the fire started; ten minutes later the Forty-sixth Street walls fell outward; and twenty minutes afterward the Forty-seventh Street wall gave way.

Many buildings of merit are more vulnerable from fire without than from fire within. The "exposure" is frequently of far greater import than risks of other character, and designers fail, as a rule, to give due weight to the value of these external hazards. The design may be such as to render it difficult for a fire to obtain much headway within the building before it is discovered and placed under control, while the same building would be most susceptible to damage if a fire should occur in the immediate vicinity.

Serious damage was done to the Manhattan Savings Institution Building, New York, through a conflagration on the opposite side of the street, during the winter of 1895–1896. This building was modern, but contained a large window area. The metal girders were unprotected, became heated, expanded, thus pushing out the walls, and finally buckled and dropped the floors.

As another example of exposure, the Methodist Book and the Horne Buildings, in Pittsburg, Pa., may be cited. These buildings were of modern and so-called fire-proof construction, yet they were completely wrecked by fire from without, on the 3d of May, 1897.

A fire started in an old building of brick and wood, partly constructed on the "slow-burning" principle, filled with combustible material, and spread to three modern steel fire-proof buildings and some five or six small buildings of ordinary construction used for shops and dwellings. These latter were completely wrecked, while the former offered resistance, although the contents were ruined. The fire was very rapid and the heat intense. The front of the Horne dry-goods store was nearly all window area and the plate glass could not resist the heat from across a street 65

feet wide. The divisional partitions were few, imperfect and badly located as fire stops, and the floors communicated through numerous openings and light wells. The adjacent Durbin Horne office building resisted better because of its divisional partitions. The metallic frames were damaged less than might have been expected, and the various systems of fire-proofing stood fairly well. The cause of the great damage was not due to the fire-proofing, but to the total disregard of the hazard of exposure.

The Horne dry-goods store contained a 5,000-gallon tank, which fell from the roof, carrying away in its flight the beams and columns. This tank was supported on a system of unprotected beams. The light court acted like a flue, and the fire on each floor was drawn to it under the draft from the broken windows.

The self-sustaining brick walls and the metal framework of the Durbin Horne office building were little injured, largely, if not entirely, due to the existence of the partitions. The floor arches resisted well, but the skew backs failed in many places. The contents were completely gutted, as the fire was fanned by a strong draft through the floor openings.

The Methodist Book Building was not subjected to the same degree of heat as the Horne buildings, and the fire simply wrecked the upper stories. This building had a concrete system of flooring.

The Home Life Building, New York, a modern "sky-scraper," became the object of a severe attack by fire on December 4, 1898.

It had sixteen stories, was 192 feet in height to the roof and 242 feet to the top of the tower. There was a light well in the middle of the north side, and along this light well were the elevators and the staircase. The side and rear walls were of brick, while the front was of marble ashlar backed with brick, built solid from the foundations. The building, with the exception of the front wall, was constructed on a skeleton framework of steel. The walls, columns and girders were covered with porous terra-cotta furring, the floors of hard-burned terra-cotta blocks and the

partitions were partly of porous terra-cotta and partly of wire lath and plaster. These partitions were cut with large openings for light, finished with plain glass transoms set in wooden frames. All the windows were of plate-glass, set in wooden sashes and no shutters were used. The room walls and ceilings were plastered. The floors, except the halls, which were of mosaic blocks, were of wood nailed to sleepers, without any concrete filling. There was also a varnished base, chair-rail, window-, door- and transom-trim of wood.

On the north, there was a corner building, five stories high, of ordinary brick and wood construction, occupied as a retail clothing store. A northeasterly gale drove the flames from the clothing store against the wall of the Home Life Building and into the light well, which acted as a chimney. The fire entered the unprotected windows of the eight upper stories, and found inside a natural draft through the elevator openings. The result was the total destruction of the contents and all combustible materials of construction on those floors, practically nothing being left but the absolute fire-proof material. The plaster work was destroyed, and in all the rooms from the ninth floor up there was hardly any plaster left on the terra-cotta furring. The wire lathing used over the pipe chases in the walls and over the various irregularities in the building did not withstand the attack of the flames. This was probably due to the fact that the metal expanded sufficiently to throw off the plastering, which had little flexibility. The woodwork was completely burned. Those partitions which were cut for the purpose of inserting large transom windows near the ceiling suffered most. The glass in these transoms broke and permitted the flames to spread from room to room, thus removing the value of these partitions as fire stops.

Some of the wire-lath partitions were built directly on the wood flooring, and their failure was caused by the burning of the wood, thus depriving them of their natural support. The wood flooring was laid with an unfilled air space between it and the floor arches. This space should not have existed, and had it been filled the floors would have stood

much longer. The effect of using other material than wood for flooring is strikingly illustrated in the halls, where the mosaic blocks retained their position and were practically uninjured, although subjected to the fiercest part of the fire.

A distorted girder on the sixteenth floor probably represents the greatest damage done to any one member of the metallic frame. It was protected on the soffit by terra-cotta blocks and wire lath. It differed, however, from the other girders in having its upper chord project above the floor. The part projecting was not protected by fire-proofing material, but was boxed in with wood, forming an elevation in the floor space of these rooms. The metal became exposed to the fire and buckled.

As a fire stop, the Home Life Building succeeded admirably, for had it not been there it is fearful to contemplate what might have resulted during a gale of almost hurricane force. Taken as a whole, the building resisted the action of fire remarkably well considering the severity of the test. The fire department was powerless to reach beyond the eighth floor, and the water tank of the building was soon rendered useless. The steel structure, with the exception of a few portions, was retained without repairs. The damage to the floor arches was slight. The front wall, however, was ruined on the marble façade from the eighth story up. No doubt the destruction would have been much less had the same care and energy been bestowed upon the details of construction and finish as were given to the main framework, general plans and architectural appearance.

Only few modern tall buildings have been seriously injured by fire, but abundant knowledge has been gained from general fires to allow the making of certain statements. Judgment should not be drawn from isolated cases. Experience in fire hazards to be of value must be based on a study of many fires, as results depend as much on variable conditions, wind, draft, exposure, contents, efficiency of fire department and the like. In the same way, it is not safe to draw conclusions from experiments, unless they have been made with the greatest care to ex-

clude extraneous conditions. The unexpected is always happening, and preparations should be made for all contingencies.

BRIEF SUMMARY OF THE PRINCIPAL HAZARDS.

A tall building, having openings in the floors from the roof to the basement, resembles closely a chimney stack.

The contents and trim are the fuel in a fire-proof building, and the air enters the windows, doors and other openings to support the combustion. As the contents are beyond control, it is essential that the design should be as dissimilar as possible to that of the furnace and chimney. The air supply should be under some restriction, by keeping the windows and door openings tight, and resistance should be offered to all tendency to flue draft, by partitions and division of floors. Openings in a vertical line should not be encouraged, but when necessary for elevators and stairs such openings should be cut off from the rest of the building by fire-division walls.

It has repeatedly been proven that unprotected metal construction cannot withstand fire, nor can it be called "slow-burning." No matter how "fire-proof" a building may be, it will be ruined if there is sufficient combustible material to create a hot fire lasting for sufficient time. The metal must be kept below the point of "redness." Metallic members should be made of at least sufficient thickness to prevent rapid heating, even though they have excess of strength to withstand the stress to be actually carried.

For a building of good modern construction, the fire hazard of exposure is greater than the risk of fire within, and precautions should be taken in the original plans. This is seldom done, as the exposed sides are primarily designed for some architectural effect. A building is liable to take fire from an external hazard on every floor at the same time, a condition most difficult to control, and one that would never exist naturally from internal causes.

Modern tall buildings make most efficient "fire-stops," but they are not designed for that purpose.

Manufacturers have produced many forms of fire-proof-

ing protection, and have striven to obtain something that will not burn. Architects and engineers have given too much attention to the substance of which the fire-proofing is made, and not enough to its proper application.

No building material has better fire-resisting qualities than good hard-burned brick set in cement mortar. Most stones are injured by heat, and marble, granite, sandstone and slate are liable to disintegrate or fracture under the action of heat and water. All fancy ornamentations of stone, such as balconies, cornices, trim, etc., are extremely dangerous, from the fact that they are liable to fall during the conflagration.

Terra-cotta in certain forms has been used for trim, but it has been found that terra-cotta, while a good fire retardent, will be seriously damaged on the thin edges, and will necessitate subsequent removal and renewal. The cost of this renewal of stone and terra-cotta on the façade of a building will be much greater than the cost of the actual material injured, as much of the backing will have to be taken down although in itself uninjured. This was shown in the Pittsburg and Home Life fires.

Bonds and pier caps are frequently made of stone and subjected to great weight. As these are usually unprotected, they are dangerous, and it would be much better to use cast iron. In the same manner, stone columns carrying great weight cannot be recommended; their unreliability to withstand the action of the heat and water is an item which must be kept in mind, both from the financial viewpoint of cost of renewal and from the danger of failure, thus dropping part of the building which otherwise would have stood.

The floors should be solid to prevent the fire from spreading, and the beams and girders be well imbedded and protected so that no part of the metal will be exposed. While most fire-proofing substances have proved to be excellent, it must be remembered that there is a choice of grades, and that many of those grades are deficient in fire-resisting qualities. The greatest weakness with all floor-arch blocks is an exposed thin edge. Most arches have such an edge, covering the lower flange of the floor beams. These thin

edges are apt to break off and expose the metal. It is still an unsettled question whether hard-burned tile, porous-hollow tile, ordinary bricks or solid construction of cement is the best.

The under side of floors, forming the ceiling beneath, should always be finished flat and smooth. The custom of having a panelled ceiling, by permitting girders and beams to project below the main level, should not be sanctioned without penalty, as it is difficult to protect these important members when thus arranged and to prevent them from retaining the smoke and heat in the pockets thus formed. The consequent local heating and irregular expansion may cause serious trouble. When such projections must exist, it would be well to supply a false ceiling made with expanded metal and plaster.

In tall buildings, where the ground area is limited and valuable, it is not feasible to construct the floor without openings. Fire can only spread from floor to floor through such openings, for light, stairs, elevators, dumb-waiters, chases for pipes and wires, etc., or externally from window to window. This hazard is grave, since it can only be overcome at the cost of inconvenience and considerable expense. The modern mill construction is admirable in this regard, where the floors are solid and the openings are made in an adjoining tower-like building, or in parts separated and cut off by permanent fire walls. As both of these methods are wasteful of area, they will not be countenanced by owners of tall buildings for city use. The closest approximation to such mill practice, however, should be adopted. The elevator and stair wells should be enclosed in fire walls of brick, with all combustible material removed. Elevator entrances are usually open lattice work, a hazard which could be rectified by using fire doors or metal roller shutters that could be closed in cases of emergency. Openings for pipes and wires should be packed with non-combustible material. Any opening will act as a flue, and it is remarkable how rapidly fire will pass through the smallest crevice.

Besides the risk of fire, the hazard of water damage is seriously increased by these openings. Floors should be

water-proof, and so arranged that the surplus of water may not pass down an opening to the injury of the floor or contents below.

Subdivision of the floor area by partitions reduces the hazard very materially. Partitions act in three ways: they confine the fire; they keep it back from the floor openings or draft areas; and they diminish the rapidity of spread, giving time for assistance to arrive. Partitions that are not fire-proof are valueless and increase the hazard by preventing close approach to fight the flames and by the cost to replace. Wooden studs covered with metallic lath and plaster are not to be treated as fire-proof. Such partitions may withstand a fire, but are liable to damage to an extent as to require renewal, since the wood chars beneath the plaster and lets the nails pull out.

Partitions should not rest on wooden sills or flooring, but be built on the arches and extend to the bottom of the arches above. This precaution is often neglected. Partitions should be solid, with as few openings as possible, in order to be most effective, as openings cut for doors and transom lights decrease their value as a fire retardent.

Comparisons have been drawn between fire partitions and brick walls. It is not reasonable to expect that partitions made of 2 inches of concrete plaster on expanded metal, or of 4-inch terra-cotta blocks, can withstand the same severe punishment as a 12-inch brick wall. Both fire walls and partitions have their legitimate duty to perform, and the inspector should not underrate the hazard by mistaking the one for the other.

Fire walls are especially valuable. Buildings covering a large area should be divided by such walls. If there had been some such division in the Windsor Hotel, the building could have resisted much longer. Every one has noticed how a thin brick wall will remain standing, even though a building be gutted and every floor falls. A thin party wall will hold a fire and prevent its spreading. Curtain walls, carried on the metal "cage" frame, are not as reliable as self-sustaining walls of equal thickness.

Combustible contents must be expected, but the quantity

of combustible material in the trim and finish of a building, and the manner of its application, directly affects the hazard. The amount of wood used in an average so-called "fire-proof" building having wood flooring, base, chair-rail, door and window-trim, amounts to about 2 pounds for each cubic foot of contents, without including the furniture or movable fittings. This would exceed the weight of the metal in a skeleton frame and be equal or nearly so to that in a cage frame. Without injury to the usefulness or efficiency of a building, the amount of combustible material could be reduced by careful planning. The wood floors could nearly all be left out, or, if retained, used only on limited areas and laid thin and solid on the concrete filling. An air space under flooring should never be allowed, as it is extremely hazardous. Nearly all the door and window-trim can be made of adamant plaster, and the only wood required would be for jamb and lintel. As the edges of partitions are always rough, the carpenter usually puts on the trim with an air space behind it. This air space should be filled with absolutely incombustible and permanent material.

Bases and chair-rails are useless ornamentation, and their value could be better utilized in some form of real fire protection. It is not necessary to use wooden studding for nailing purposes, as nails will take a firm hold in terra-cotta. In general, all woodwork should be omitted except where absolutely necessary, and then used on the slow-burning principle.

Windows are dangerous because they let a fire enter from without, and supply air and draft to a fire within. In consequence, they should be as small in size and as few in number as the circumstances will permit. They should be protected with shutters. When shutters are not feasible, wired glass should be used, and in exposed positions the glass should be doubled, with an air-space between. There is no reason why wired glass cannot always be used for windows on elevator and stair wells, and for door panels and transom lights. Wired glass has one advantage over shutters, in the fact that windows are less likely to be left open.

The main parts of buildings should be made self-supporting, no matter what happens. Heavy weights, such as tanks, elevator appliances, cornices, balconies, and the like, should be so constructed as not to fall, except in cases of total destruction. The hazard from falling weights is most serious in impeding the firemen, in breaking openings through the floors which would act as draft flues, and in damaging parts of the structure which would otherwise have been uninjured.

Smoke flues cause an annual loss to the insurance companies doing business in the United States of upwards of $20,000,000. In modern tall buildings, however, the hazard from these flues is reduced to a minimum, on account of the manner in which such buildings are constructed.

Expansion and contraction cause hazards which cannot be neglected. Every material used in construction expands on the application of heat, and the amount of expansion is not uniform. In composite construction—that is, where part is metal and part stone or brickwork—the difference in the lengthening of the various subdivisions in a tall building may be sufficient to create severe cross strains that may cause failure of certain details which otherwise would have withstood the heat. In many fires, external and fire-division walls have been thrown down by the expansion of the main metallic members. The design should provide allowance for expansion in all parts where the amount of lengthening would cause damage or failure.

There can be no question but that there is a hidden hazard in metallic members subjected to rust. Rust is a process of slow combustion, and, if allowed to progress, will eat away the members to an extent that may render them so thin as to heat rapidly, or to fail under a normal load. Metallic members, therefore, buried in masonry cannot be considered as safe as those which are located away from such masonry and protected with some good fire-retarding covering, which could be removed from time to time for the purposes of inspection.

In a broad sense, there are two separate methods of construction—one of them monolithic in character, the

other built up of small pieces, joined or cemented together by some different substance. Monolithic construction has the great advantage of solidity and uniformity, and from it small pieces are not apt to fall or break out, thus forming draft areas or flues. On the other hand, the financial hazard of such construction is great, for, if any damage is created, a greater quantity of good material must be taken out and replaced than if the construction were made up of smaller pieces.

A building of the Walker Soap Works, in Allegheny City, was exposed to fire on May 25, 1899. The fire occurred in a brick building 14 feet away, and for the time was very intense. The building was built of steel framework, filled in with cement walls, retained on expanded metal. The construction was monolithic, and withstood the heat with but slight injury, although the brick building was greatly damaged.

One of the most serious troubles is the alteration of the plans after the work has been started. The original design may call for a well-protected building, but, through carelessness of inspection or the desire to save a little money, the character of the building may be changed to a veritable fire-trap.

The question naturally arises whether it pays the owner to make a building thoroughly fire-proof. Unfortunately, there are many who build for the specific object of obtaining the greatest income from a minimum outlay, and the effort to save on the first cost is so great as to render their judgment valueless as to what should or should not be done. Tall buildings of cheap construction are a menace not only to owners and tenants, but to the community. In any building there must be, and always will be, an amount of combustible matter that cannot well be reduced.

Owners frequently locate floor openings so as to take up a minimum floor space, and thus render a maximum area available for income-earning purposes. Nearly every builder estimates the amount of space devoted to public use, and concludes that the best building is the one that has given up the least percentage. While this effort is

commendable from a purely income-earning standpoint, it often renders the design dangerous to life and property, and frequently makes it impossible to design a building under such conditions that shall be fire-proof. When stairs and elevators are placed together in the same well, there must always be a strong tendency to cut off means of escape and means of saving property from floors above.

Even in a fire-proof building dependence must be had upon human aid; and when the building is tall, it towers beyond the reach of any fire department.

A fire in the lower part is easily accessible, and the hazard most dreaded is that of a fire in the upper stories. The water tanks as usually supplied on roofs of tall buildings are inadequate in capacity. Unless the pumping plant of the building be so situated as not to be injured or rendered useless, the tank hardly pays for its cost in cases of severe fire.

Owners do not hesitate to spend thousands of dollars on fancy marble panelling, architectural carving and similar ornamentation, and will refuse to spend a few hundred dollars to have plans properly prepared and to see that the dangerous parts are constructed with that care which a really fire-proof building should demand.

From the viewpoint of the fire insurance companies, it appears as if such companies had no interest in actual fire-proof construction. Such should not be the case, for anything that will tend to reduce the fire hazard will necessarily tend to reduce the fire loss. The gross business of the companies might be reduced, but the net income would be increased. Unfortunately, they do not act in unison, and each one seeks risks which are dangerous in character, through a sheer spirit of competition. The influence for good that could be exerted by insurance companies is great, provided they would properly classify their risk, charging penalties or reducing their rates in accordance with the elements of design and the means employed to secure really fire-proof construction.

CHEMICAL SECTION.

Stated Meeting, held Tuesday, November 21, 1899

THE INFLUENCE OF SCIENCE IN MODERN BEER BREWING.

BY FRANCIS WYATT, PH.D.,
Member of the Institute.

It is only fair for me to assume that the majority of you have given very little attention to malt liquors from the standpoint of their industrial production. You are, however, all well aware that beer is one of the oldest alcoholic beverages known to man; and that its age can be traced backward and backward until its history is buried under the *débris* of antiquity. It must have been the most popular beverage in Egypt some 500 years before the Christian Era, because Herodotus describes its qualities and says that it was made from barley malt; and that Isis, wife of Osiris (Rameses II, 1960 B.C.), was the mistress of the art of brewing. Diodorus Siculus, Plautus, Pliny, Strabo, Tacitus and Virgil all make frequent references to barley wine; and we know that the Romans did their best to promote the art of brewing in Britain. In the laws of Ina, king of Wessex, regulations are provided for the sale of beer, and the ancient Danes and Germans were as famous as their descendants still are, for brewing, as well as for drinking it. In comparatively recent times, Edward, the Confessor of England, was much addicted to spiced ale; and Henry III enacted a law fixing the price of malt liquor in cities at 1 cent per gallon, and in the country districts at the same price for 2 gallons. During the reign of Queen Elizabeth, the use of beer by all classes was so popular and general that a quart of good ale for each meal was the usual allowance for each individual. In the year 1690, when the amount of beer produced and sold by the licensed brewers of London amounted to a little more than 2,000,000 barrels, it was

made the object of a tax by the government at the rate of 60 cents per barrel; and as a mere evidence of the effect of taxation upon its comsumption, and the way in which history repeats itself, it is very interesting to note that when, in 1692, the tax was doubled, the consumption of beer fell off to 1,500,000 barrels.

In the United States of America there were in the year 1810 about 130 breweries, and their total product was a little less than 200,000 barrels per annum—all ale or porter, and all brewed on the time-honored plans of the English. In 1842 the manufacture of lager beer was introduced from Germany, and in 1850 the total production of malt liquors had risen to 750,000 barrels. In 1863 this had increased to 2,600,000 barrels, and until that time no record can be found of any interference on the part of the scientist. On the contrary, the utmost simplicity of method and ignorance of science everywhere prevailed, as may be gathered from the following quotation from a memorial which was officially presented to Congress by the United States Brewers' Association, as a body, in the year 1865, in connection with the determination of the proper method of collecting the governmental tax on fermented liquors:

"It may not be out of place to call your attention to the peculiar characteristics of the brewing business, and the circumstances which determine the marketable value of beer. To those practically acquainted with the manufacture of malt liquors, whether ale, porter or lager beer, we will be sustained in the opinion that in scarce any other branch of manufacturing are there so many obstacles to the production of a marketable article as in that of malt liquors. Limited as the brewer is to the use of barley for the manufacture of his malt, and to hops for which (as a pleasant and aromatic bitter and preserver of his perishable commodity) there is no substitute, though wet harvests may have rendered the former unsound, and unpropitious seasons impaired the strength and value of the latter, he is compelled to use them. To unsoundness in the grain and the blight of the hop (which has so alarmingly manifested itself for the last few years in the agricultural districts of

this country, and the consequent difficulty of obtaining a sufficient quantity of the best qualities to insure the keeping of the beer for any length of time) are mainly attributable the losses of the brewer, which, in this country, have been in some years so disastrous as to cause bankruptcy in many instances. An eminent and long-experienced and established brewing firm of England had not less than 20,000 barrels of beer returned to them by their customers in one year as unsalable. The sudden atmospheric changes ofttimes impair the quality of the beer. Unavoidable exposure, in transporting it from the brewery to a distant point of consumption, to severe cold, destroying its briskness and rendering it vapid and unpalatable, or to the summer's sun, which may cause acidity and the bursting of the casks, contribute to the disappointments and heavy losses to which the business is liable."

It will be seen from this that, despite its antiquity, brewing had made but little progress, and the working brewers themselves were in a state of the profoundest darkness. The product was, at the most and best, uncertain in all those qualities by which a beverage earns the title to be regarded as a food by the people. Nor is this in any way strange, for what can be expected from any industry conducted in ignorance of its elementary scientific principles? While an art is shrouded in mystery or practiced by secret methods; while there is no intercommunication of an intelligent nature between fellow-craftsmen, how can progress be expected? how can uniformity of product be realized? or how can the commercial operations connected with it be conducted without loss? I might cite innumerable instances—and so, I am sure, might you all—where strictly practical men, working on rule-of-thumb lines, without the least philosophical reasoning as to the why or wherefore of their processes, nevertheless have succeeded in doing excellent work according to their lights, and in furnishing products more or less answering to the public demands. So long as no change was rendered desirable by expediency or alteration of public taste, all would go well; but, directly the long-trodden path was abandoned, directly there was a

modification of raw material, or an alteration in the arrangement of the plant, or a desired change in the quality of the product itself, these same workers were beset by difficulties which they had no means of combatting, and which they could never overcome. Could none of us call to mind, at this moment, industrial establishments which were once at the height of prosperity, the glory of their environment, which commanded the highest market prices for their products, and enjoyed the uniform preference of the world? Where are they now? Have they sunk into insignificance or oblivion? Why, if not by reason of an intelligent and increasingly scientific competition, with which they were totally unable to cope?

If we look into the manner in which the brewing of malt liquors developed into a trade, and how, from a mere "art and mystery," it has developed into a science, we shall find that the condition of affairs which now prevails has been brought about solely by the development of scientific, not to say strictly chemical, knowledge. Do you suppose the ancient brewer knew anything whatever about his raw materials? Had he, do you think, any other reason than tradition or custom for any of his manufacturing processes? He was, I take it, absolutely blind to the phenomena of plant growth and of fermentation. The home-brews were made in the kitchen, or in the wash-house kettle; and from the meager accounts at our disposal, I gather that, up to within sixty years or so ago, even those beers which were brewed for sale in breweries established for commercial purposes were produced in so crude a way that very little difference in quality can have existed between the brews of Betty, the cook, and of Jones, the public brewer.

One thing is certain: What the malt liquors of those days lacked in other qualities they made up in alcoholic strength. In the light of our present knowledge, we can see that this excessive quantity of alcohol was essential to their stability; and was, in fact, the only means that could guard them against decomposition or undue acidity. They were dark in color, and necessarily very intoxicating; and they were probably well adapted to the needs of an older

and more athletic civilization. They would certainly not have suited an age of nervous, excitable, restless and overworked people, who live up to the doctrine of the "survival of the fittest," and are compelled to adhere to the laws which accord all the prizes in life's battle to the swiftest and the strongest. As I understand it, such a people as the latter require a beverage that must be nourishing as well as slightly stimulating; and which can only find complete favor on condition of possessing many additional qualities that appeal at once to the epicure and to the modern esthete. The half-sour, muddy and intoxicating ales or beers of our ancestors were naturally doomed to disappear or to fall into disfavor along with the manners and customs of their times, and their disappearance was hastened and facilitated by the practical applications of modern scientific education. This, I suppose, has been the course followed by nearly every industrial product of any importance throughout the civilized world; but in the case of the brewer it has not been followed in gigantic strides, but rather by a very slow and tortuous process of natural evolution, which has always been discouraged by his inertness. Time was, within my recollection, when practical brewers laughed at science, and scoffed at the scientist, but very gradually, and step by step, they have been brought to adopt the discoveries of science into their daily work; and so, unknowingly, and despite themselves, they are literally carrying on to-day, by "rule-of-thumb" methods, what I may with perfect propriety call the most intricately scientific processes of modern times.

Science schools and universities in all parts of the world have helped us along by fostering investigations of the laws which govern the fermentation industries, and I believe that there are few other branches of manufacturing which can claim to have enlisted the services, and to have enjoyed the discoveries, of more truly great scientists and disinterested investigators. An enormous amount of laboratory work has necessarily produced vast quantities of literature on the subject of fermentation and micro-organisms, in every known language, and it would be manifestly absurd

for me to attempt in one brief lecture anything more than a mere glance at the actual "influence of science in modern beer brewing."

The theory of modern beer brewing, as you will readily understand, is based primarily upon the results of a complete study of the nature of all the materials entering into the composition of beer, and of all the various microscopical fungus growths which, under normal conditions, cause the worts to undergo fermentation, or, when conditions are abnormal, bring about their spontaneous decay. The modern brewer must therefore be well grounded in science. He must be mechanic enough to know all about the structure of his complicated modern plant, the working of his various forms of pumps, boilers, engines, ice machines, etc. He must be an engineer and understand all about combustion, fuel consumption, cold production, efficient drainage and proper ventilation. Finally, he must have an adequate knowledge of chemistry and biology; and, in short, must depend upon science generally for the good qualities of his beer, and the maximum return from his materials. The prevalent fallacious notion among ignorant people that, if the production of beer is to be regulated by chemists, indiscriminate use of chemicals in its manufacture must follow as a natural consequence is, of course, absurd; the truth of the case being that we can only make real economies in any industry—and especially in the brewing industry—by discarding old-fashioned processes and faulty materials, in favor of processes and materials that will increase the output of the plant without any corresponding increase in machinery, labor or storage capacity. In every great industry in the world the chief modern developments have been made in the direction of increasing production and lessening cost, while improving the article produced. This is in accordance with what we all consider to be natural and fair, and it should certainly enter into no man's mind to question or doubt its perfect propriety. When science found the means of making cheaper or better steel by eliminating some elements from, and adding other elements to, the original pig iron, no outcry was made about adulteration or inferiority.

The steel manufacturer of to-day sells his steel under guarantee that it shall conform to certain tests of strength and quality; and, providing that it does so conform, everything is satisfactory. The farmer who was hitherto only able to grow 12 bushels of wheat on his acre of land has been taught by chemistry that the reason for this is the poverty of his soil; but by manipulating that soil according to chemical formulæ, reducing this and increasing that ingredient, putting in some element that was lacking before, he succeeds in producing 30 or 40 bushels of wheat upon his acre. Has it not been said of this man that by producing two blades of grass where only one grew before he has done more good to his country than a whole host of politicians? I take it for granted that you admit all these truisms, and I may come at once to the essence of my subject.

The process of brewing always was and still is nothing more nor less than the art of preparing an alcoholic drink by the fermentation of prepared cereal grains. As known to and practiced by us to-day, it is divided into two main operations:

(*a*) Chemical, and

(*b*) Biological.

(*a*) In malting a certain proportion of barley, in order to cause its germination, and to thereby produce the required changes in its composition. When this malt is finally ground and mixed with water at proper temperatures, its soluble constituents go into solution. This solution is then boiled with hops, and, when sufficiently concentrated, is cooled down to the desired temperature.

(*b*) In fermenting this boiled, cooled liquor by mixing in with it a certain quantity of beer yeast (Saccharomyces cereviciæ). When the fermentation has come to an end, the fermented liquor is stored in vats in properly-constructed cellars until sufficiently mature for consumption.

Looking at these operations as thus outlined, the brewing of modern beer would not appear to the uninitiated to be a very intricate operation, and would probably offer no startling aspects of revolution or novelty to the brewer of 500

years ago. I am, however, going to prove to you that whereas our ancestors were groping in the dark, we are now enjoying the light of science; and where they were working haphazard, we are now working on such scientific principles that we can, when we commence to make a brewing, foretell the kind of beer we are going to produce with scientific accuracy. I have already shown the great trouble with the old brewers—and even with comparatively modern ones who adhere to old ideas and methods—by reading to you an extract from their own petition to Congress in the year 1865. Their beers became cloudy and formed voluminous deposits within a very few days after being placed upon the market, and rapidly became acid, unpalatable and unwholesome, owing to processes of secondary fermentation and spontaneous decay. The only known means of partially overcoming these defects was to arrange for great alcoholic strength.

When chemists came into the field and commenced their investigations on the brewer's behalf, they very soon proved beyond discussion that these defects were due in every case either to naturally faulty or ill-made raw material, or to defective processes of treating that material during the mashing process; or to the impure character of the yeast; or to the impure nature of all conditions surrounding the brewing premises. The various wild yeasts and bacteria which constantly swarm in the air and infest all liquids which are exposed to their ingress fed upon the excess of proteid matter which all these old-fashioned beers necessarily contained, and decomposition, or putrefactive fermentation, invariably ensued, even in cases where an abnormal amount of hops had been used, and where a large proportion of alcohol to act as a preservative had been produced.

I have stated that the essential constituents of all malt liquors are derived from the chemical transformations of starch. These constituents are alcohol, unfermentable extract and carbonic-acid gas. The most precious qualities of all malt liquors—flavor, odor, brilliancy, stability and healthfulness—are chiefly attributable to pure and healthy fermentation.

Of the various cereals now used in the production of

modern beers and ales, the following is the average composition :

	Malt.	Corn Grits.	Rice.	Barley.
Moisture	4·00	10·50	10·60	12·00
Starch, sugar and gum	68·00	76·40	81·00	60·00
Fat	2·25	0·65	0·10	2·50
Nitrogenous matters (soluble)	4·00	0·00	0·00	0·00
Nitrogenous matters (insoluble),	8·00	11·00	7·20	12·00
Mineral matters	2·25	0·45	0·90	2·50
Cellulose or husk	11·50	1·00	0·20	11·00

From a superficial glance at these materials it would seem that the difference between the composition of the raw grains and the malt, as exhibited by my figures, is so extremely small as scarcely to demonstrate the utility of so costly and tedious an operation as malting. We must remember, however, that there are numberless phenomena constantly occurring in nature, productive of very familiar effects, which it would be impossible to explain on the basis of an analytical tabulation, and to this kind of phenomena the transformations in malt belong. The substances classed in the analysis of raw barley as nitrogenous, for example, are almost entirely insoluble in water. In my analysis of malt, on the other hand, it is shown that one-third of these nitrogenous bodies are soluble ; and hence it is evident that they have undergone hydration during the malting process, and have been thus degraded to a lower and more assimilable state. It is these soluble nitrogenous matters, of which diastase is one, that form the basis of the mashing process; and it is they which cause the series of chemical changes which take place in the mash-tub.

It is not necessary to go into details concerning the very complex chemical composition of diastase, and I shall be satisfied with the statement that, under suitable conditions of temperature and moisture, it will convert many times its own weight of starch into sugars and dextrines ; and that consequently the composition of a well-prepared brewers' wort is made up of the following substances, in variable proportions :

Maltose ;
Malto-Dextrines ;
Dextrines ;
Albuminoids or Proteids ; and
Mineral Salts.

Now, one of the first things that attracted the attention of chemists was the fact that all malts of good quality, and especially such of them as have not been subjected to too high a heat during the mashing processes, contain much more diastase than is needed to hydrolize their own starchy materials. This fact led to the formulation of the following proposition:

(*a*) The starch of the grain is the substance from which beer worts derive their main constituents.

(*b*) The starch of malted barley is in all essential respects identical in composition with the starch of raw barley and all other cereals.

(*c*) The diastase of malt is capable of converting much more than the quantity of starch with which it is associated.

(*d*) The chief troubles in finished beer are occasioned by the excessive quantity of nitrogenous bodies that pass into permanent solution in beer worts, made from malt and hops only.

This proposition, having been put to the test by practical experiment, has demonstrated that it is expedient—and indeed essential—to combine with malt a sufficient proportion of outside starch, in the shape of raw cereals, to more completely utilize the diastase; and, at the same time, by creating a greater mass of material, to diminish the proportion of alterable proteids.

Another factor of prime importance in all brewing operations is the nature and quality of the water supply.

This determination of purity or unfitness, of course, falls to the lot of the chemist-biologist, and it will not be amiss to glance at the qualities which distinguish good from bad water for brewing purposes.

The general objects which a chemist has in mind when he is called upon to examine a brewery water may be thus stated:

(1) Is it adaptable by its hardness or its softness, or its organic purity, for the general purposes of malting or brewing, or boiler feed? Or,

(2) Does it contain any organized or unorganized poisons

which would make it deleterious to the process or the product?

Not only must waters of bad taste and smell and carrying considerable amounts of foreign matters be rejected, but many others which are not only agreeable to the taste, but colorless, odorless, and containing very little suspended matter, are often the abundant sources of disaster and faulty fermentation.

The complete analysis of a brewing water, after it has been freed from insoluble suspended matter, should show how much it contains of the following elements:

(1) Hardness before boiling.

(2) Hardness after boiling.

(3) Total solid residue after evaporation.

(4) Residue after calcining the above at low red heat.

(5) Bases and acids.

(6) Free ammonia.

(7) Albuminoid or organic ammonia.

(8) Oxygen required to oxidize the organic matter in five minutes at 80° F.

(9) Oxygen required to oxidize the organic matter in three hours at 80° F.

(10) Nitrous acid or nitrites.

(11) Nitric acid or nitrates.

The salts that are most looked for, because the most important in a brewing water, are the sulphates and carbonates of lime, magnesia and soda, and the chlorides of sodium and potassium; and it may be here broadly stated that the combined total quantity of the earthy sulphates and carbonates should never exceed a maximum of, say, 100 parts per 100,000. I make this statement from my own practical experience in the laboratory and the brewery, and base it on a careful observation of the following facts:

(*A*) The sulphates and carbonates of lime and magnesia in the water interact upon the soluble mineral matters contained in the malt, and produce insoluble phosphate salts, which are left with the spent grains in the mash-tub. This, of course, unduly restricts the mineral food of the yeast.

(*B*) When the proportions of sulphates and carbonates

of lime and magnesia are greater than a maximum of 100 parts per 100,000, they have too great a deterrent action upon the formation of soluble nitrogenous matters during the malting process. They also unduly neutralize the required acidity of the worts, decrease the yield in total extract obtainable in the mashing process by from 5 per cent. to 6 per cent., exercise too great a restricting action on the diastase of the malt, and somewhat retard the final attenuation and clarification of the beers.

The salts which are of very rare occurrence, but which should always be the object of careful research, are those of such metals as copper, lead, zinc, chromium and iron, and all samples of water which contain anything more than the merest trace of any save the last-named should be condemned. When the iron in a brewing water does not exceed half of 1 part per 100,000, it has been proved that no evil effects are produced on the beer; but when it exists in larger quantities than this it becomes highly objectionable from its faculty of forming hop-tannates of a dark and disagreeable color and taste. It is best got rid of by aeration and precipitation as red-oxide, or by boiling, and adding a small quantity of powdered chalk.

It must be remembered that some single factor, resulting from the purely chemical analysis of water, may be altogether abnormal, and this, of course, is attributable to our lack of direct methods of investigating organic matter. The difficulty of interpretation is rarely caused by excess of chlorine or of the mineral salts, but is invariably to be found in the inconsistency of one of the numbers found either by the "oxygen" or the "ammonia" methods. The necessity for evidence of a kind which analytical tests alone are unable to supply is, therefore, manifest; and this evidence we seek by means of the microscope. To put it more plainly, wherever there is room for serious doubt as to the organic purity of a water to be used in a brewery, it must be examined biologically, and the vitality and nature of the micro-organisms contained in it must be made the gauge of its fitness or unfitness for use.

This bacteriological examination of water is fortunately

not a complicated operation, and can be conducted in a very simple manner. For all practical purposes it is merely necessary to mix a measured quantity of it (usually 1 cubic centimeter) with a proper sterilized, nutritive solution, in vessels protected from the air. This mixture is kept at a uniform temperature, and the microbes will soon have attained a sufficient development to be counted under the microscope. In my own laboratory I adopt malt wort as the culture medium, after it has been sterilized by boiling it in Pasteur flasks. The subsequent entrance of outside germs is prevented by closing the openings of the flasks with plugs of sterilized cotton wool as soon as the boiling is finished, and the wort preserves itself indefinitely after this without losing its brilliancy or undergoing the slightest change.

The water to be tested is well shaken up to insure perfect homogeneity, and 1 cubic centimeter of it is introduced into one of the sterilized wort flasks by means of a pipette sterilized in a gas flame. The flask is kept at a uniform temperature of 80° F. for three or four days; the behavior of its contents is very carefully and constantly watched, and a drop is taken out from time to time, in order that the development of micro-organisms may be examined under the microscope. As the operation is always conducted on exactly the same lines, it yields most useful and reliable data. If a water develops very active fermentation and very large numbers of organisms in the flask, we have undoubted proof of the existence of various species of bacteria, which are liable to cause trouble in beer; and this evidence must be taken as sufficient to forbid its use.

The fact that waters of medium permanent hardness are the best adapted for the production of the modern type of malt liquor has been established by experience, and is now very generally admitted by all those who have knowledge of the subject. It does not necessarily follow, of course, that good beers cannot be produced from relatively soft waters, or that any water which is good enough to drink is not good enough for the purposes of brewing. What I mean is that a large number of soft waters which have been used, and

are still being used, for brewing, and which are quite good and pure as they stand, may be vastly improved as beer-makers by the addition of certain hardening salts in moderate proportions.

When the chemist has finished with the water, he comes naturally to the barleys used for the production of malt, and here I may state broadly that the quality of malting barley mainly depends on the nature of the soil and the climate in which it is grown. Cold clay lands are unsuitable for its growth, and a warm, friable, calcareous loam is the best natural soil.

The essential qualities of malting barley are *vitality*, *condition*, *maturity* and *odor*. By vitality is understood growth capacity; and all barley designed for malting purposes should contain a minimum of non-germinating grains. In order to test a barley for its growing capacity we use what is known as the "germinating apparatus." This consists of a receptacle for water, a germination tray, and a felt cover, fitted with a thermometer. The corns to be tested are placed on the germinating tray and the necessary moisture for germination is derived from evaporation of the water in the receptacle underneath. In this way excess of moisture is avoided. The tray is constructed to hold exactly 100 corns, and, if the germinating capacity is uneven, the non-germinating corns can be perceived and counted.

It is customary to collect and classify all the nitrogenous bodies present in barley under the general term albuminoids. Very little is really known with accuracy as to the changes which these nitrogenous bodies respectively undergo during germination of the grain. Some of them become soluble in cold water; others do not. Of those which are soluble in cold water, some are coagulated by heat at temperatures varying from 105° F. to 212° F. Diastase belongs to these soluble, coagulable albuminoids, and so does peptase, which has been found to have an action on the albumens of the barley during the malting process similar to that of diastase upon starch.

One of the main objects in malting, in fact, is to induce the changes in the nitrogenous constituents of barley. From

the first moment of germination peptase begins to work. The insoluble nitrogenous substances acted upon by it become soluble. As fast as this solubility is effected, some of them are transformed into certain non-albuminous crystalline substances soluble in water and highly diffusible, known to chemists as amides.

For brewing purposes it is generally understood that a barley rich in albuminoids is not the best for malting purposes or for the production of sound beer. A malt rich in albuminoids is always low in percentage of starch. The wort resulting from such malt is poor in saccharine matter, and the finished beer is generally cloudy and unstable.

In regard to malting, the aim of the modern maltster is not to produce the most perfect development of the barley germ, and thereby the most flourishing and productive plant, but to simply develop sufficient vital activity to realize the required transformation uniformly throughout the entire mass and at the least possible expense of material, time and money. A certain quantity of water and a certain degree of temperature bring the embryo into activity. It commences by secreting those substances which are capable of reducing its food to an assimilable condition. The diastase, which transforms the starch into sugar, is thus formed; the insoluble albuminous matters, which could not be diffused through a membrane like the yeast cell, are acted upon by the peptase and transformed into peptones and amides.

The maltster allows the embryo to act upon the endosperm sufficiently to prepare the latter as its food, but he does not allow it to consume the food after its preparation. We do not require a maximum development of the germ. We are careful not to use optimum temperatures, and we seek for that point at which the transformation may go on equally well throughout the innermost parts, and stop when that point is reached.

The kilning of malt after germination is finished does not imply a simple desiccation or drying of the germinated grain. Its object is not merely to definitely stop the growth and confer keeping qualities, but to bring about certain

chemical transformations which will enable us to brew a healthy, palatable and stable beer of any desired color, taste or smell. A good malt must be perfectly well cooked. It must yield a high amount of extract, and the worts that run from the mash-tub must be brilliant and stable.

Too high an acidity in a malt may in many cases result from a primitive defect in the unmalted grain, but more generally it results from unskilful malting. A very high percentage of acidity in malt generally produces a complete disturbance of the albuminous constituents of the wort, and the ratio of the so-called peptones and amides is considerably and disadvantageously modified.

A good malt cannot be too friable; it should be so crisp that a grain taken between the finger and thumb should be easily crushed, the inside portion falling from it in a fine, granular powder. There are two things absolutely necessary to obtain a good malt: A very complete disaggregation of the entire substance of the grain during the steeping, and a very slow drying on the malt-kiln at a very low initial temperature, combined with a very free circulation of pure air. The first temperature on the kiln must be about 100° F., with a very great draught; the second, about 130° F.; the third, about 150° F., and then we may go to 180° F., with the air shut off, or as much higher as may be necessary, according to the quality of malt desired. These temperatures have been fixed by chemists, and they are based on sound, scientific principles. If we pass a measured volume of air over any damp or wet body, we find that the air will take moisture from that body until the point of its saturation has been attained. The point at which air becomes saturated with moisture depends, as you very well know, upon the temperature of the air itself. The hotter it is, the more moisture it will take up. Consequently, the wet or green malt might be dried very rapidly by very hot air, but this is what we want to avoid, especially at the beginning, for if we dry too quickly, we shall dry from the surface inwards, whereas what we must aim at is to so regulate the temperatures and the volume of the air as to commence the drying from the inside outwards, gradually

increasing our temperature as the operation approaches completion. The higher temperatures employed in finishing off the malt on the kiln undoubtedly determine its quality and general character, and we may produce at will malts that are known as pale, brown and black and medium and high-dried. From a practical point of view, the utmost advantage and economy result from using high-grade, high-dried malts in brewing. They give a pale beer and possess excellent diastasic power. They favor to the maximum the reproduction of yeast, and secure a very desirable degree of fermentation.

Of all the bodies contained in malt, diastase is the most sensitive to the effect of heat and moisture, and this is a point which chemists have now succeeded in impressing upon all maltsters and brewers. It has been demonstrated to them in practice that the kilning process undergone by malt has a diminishing influence on diastasic activity, and I will give you a few figures to prove this:

Temperature.	Moisture.	Diastasic Power.
140° F.	7·00	168
150° F.	5·00	145
160° F.	4·20	120
175° F.	3·10	105
190° F.	2·05	87

Speaking in a general way, a given weight of green malt taken from the germinating floor will generally exhibit the same amount of diastasic power as the same weight of a well-made, well-kilned malt fresh from the kiln. The green malt, however, contains from 40 to 50 per cent., by weight, of water, and thus a great portion of the diastasic power is naturally seen to have been destroyed during the kilning. The amount of destruction varies in proportion to the quantity of water, and there is no doubt that in this respect diastase shows itself to be akin to all the other albuminous substances that have been investigated. The protoplasm of the microbe cell will stand without injury an amount of dry heat which would immediately overcome it were the heat to be suddenly charged with moisture. To sterilize a solid body of the nature of starch would require a dry tempera-

ture of about 350° F., whereas in the presence of water or moisture a temperature of 212° would rapidly kill all germs. If we were to enter a room or chamber heated up to, say, 170° F., and devoid of all moisture, we should probably be able to walk about it pretty freely, but if we went into an adjoining room, heated to the same degree and containing an atmosphere saturated with water, we should find it impossible to remain even for a few moments.

It is generally admitted, and has been demonstrated by careful experiment, that the maximum saccharifying activity of diastase is exhibited at a temperature of 140° F., at which it has the power of changing gelatinized starch into four molecules of maltose and one double molecule of dextrine. This hydrolizing action does not take place suddenly, but occurs very gradually and by successive changes. It is believed to commence by breaking down the starch molecule into a molecule of free maltose, and a molecule of very complicated form, which we call malto-dextrine. This latter molecule, by continued action of the diastase, is broken down into free maltose—a less complicated form of malto-dextrine and free dextrine. Slowly proceeding in this manner, the ultimate conversion product is a maximum of maltose and a minimum of dextrine.

If, instead of being maintained at 140° F., the solution of diastase or the mixture of malt and water is heated at the initial stage to a high point—say, for instance, to 155° F.—the actual activity of the diastase is much increased, but its converting power is seriously lessened. It will still be able to very freely effect the transformation of starch, but the conversion products will not be the same as those produced by the lower temperature. They will consist of much less free maltose and much more complex malto-dextrines, as the final outcome. And this effect will be a permanent one and, when once produced in the mash-tub, will not be changed by any subsequent alteration of temperature. It follows from this that chemists have taught the brewers to use the utmost caution in attaining what is known in practice as the converting heat of the mixture of malt and water, because it is this converting heat that absolutely determines

the proportion of directly fermentable matter desired in the wort before it is mixed with the yeast.

Applying these facts to the process of saccharification in the mash-tub, we shall presently see that, according to the power of the diastase, and the temperature at which that power is developed, we may produce variable proportions of the products of starch conversion—maltose, malto-dextrines and free dextrines—and thus have a means of predetermining, with approximate accuracy, the character and composition of our beers.

Let me now turn for a moment to the use of those starchy or saccharine materials which are known as malt substitutes, or malt adjuncts.

The proportion in which these materials are used varies, of course, with different circumstances and conditions, and it is safe to say that it may range from 20 per cent. to 40 per cent.; the average, however, being about 30 per cent., by weight, of the total extract required in the brewing.

Large sums of money have been invested in this country in machinery to manufacture these materials, and their use has brought about a vast improvement in the quality of the beer brewed. They modify the malts, which vary somewhat from year to year, according to the season, and, speaking generally, accomplish the following objects:

(1) They diminish the percentage of alterable proteids in the finished beer, the presence of any excess of such proteids having an invariable tendency to provoke instability and produce cloudiness in the finished product.

(2) They give a pale color and more effectual and rapid clarification, and a softer and fuller flavor.

Rice, which is largely used by brewers on account of its high percentage of starch, and its freedom from soluble nitrogenous matters and oil, is a brewing material of the very first class.

Maize or Indian corn, from which our commercial corn grits, corn meal, flaked corn, etc., are obtained, cannot be used in its natural state in the brewery on account of the large quantity of oil which it contains. In order to fit it for brewing purposes in either of its various forms, it first

undergoes a somewhat intricate mechanical treatment. The whole maize is put through a mill which deprives it of its hull and of its germ, the germ being that portion in which the major part of the oil is contained. The kernel thus hulled and degerminated is passed through a series of knives or choppers, and the product is divided up into various categories, according to its fineness. Thus, hominy is the name given to the very coarse particles; grits are somewhat finer than hominy; and the fine flour is called meal. It must be noted that the large particles contain the least oil. Thus, for example, while the original maize generally contains on an average 5 per cent. of oil, well-prepared hominy does not contain more than 0·5 per cent. Well-made grits should never contain more than 1 per cent., while corn meal will generally contain from 1·5 per cent. to 2 per cent. In the course of preparing grits on a large commercial scale for the use of brewers, the millers find various sources of profit. For example, a very fine flour or meal is sold for cooking purposes. A somewhat inferior grade is mixed up with the powdered husk and sold as cattle feed. The separated germs are subjected to a treatment by which the oil they contain is extracted from them, this oil being a very valuable article of commerce, either for the purpose of food, or as a lubricant, or as an ingredient in the manufacture of the finer soaps.

Flaked maize and flaked wheat are both excellent brewing materials, and are made by first removing the husk and the germ and pressing the starchy portion between steel rollers in order to flatten it out and break it up. The flakes are finally dried by hot air. The great advantage of using prepared cereals of this nature is that they may be put directly into the mash-tub, together with the malt, and require no previous conversion in a separate brewing vessel.

Grape sugar and glucose have long been favorite brewing materials, and are both made by boiling starch with a weak acid. When starch is boiled, either with or without pressure, in presence of a weak acid, such, for example, as very dilute hydrochloric acid, it is rapidly hydrolized or transformed into dextrine and maltose. These, by further

boiling, are nearly entirely transformed into dextrose or grape sugar. When the desired transformation is effected, the hydrochloric acid is neutralized by carbonate of soda. Chloride of sodium is thus formed. The liquid is then passed through charcoal in order to bleach it, and is finally evaporated to any desired consistency.

In regard to the use of unmalted cereals in brewing, it must be borne in mind that their starch granules are contained in cells. These tiny cells must be ruptured before the starch can be acted upon by diastase. To effect the rupture of these cells, it is necessary to resort to gelatinization with hot water. In the case of malt it will be remembered that the process of malting partially liberates the starch by softening or dissolving the cell walls. The malt starch being thus rendered more sensitive to the influence of hot water, the comparatively low temperatures of the brewer's mash process are sufficiently high to effect its gelatinization. Very high temperatures are required, however, in order to free the starch granules of raw grain, and this is why when brewing with it two distinct mashing operations are performed. One of the operations consists in boiling the raw grain itself for a sufficient length of time to render the starch available; the other operation consists in mashing the malt at a low temperature and thus preparing the diastase to act upon the starch of the raw grain when the two mashes are brought together in one tub.

As a matter of actual practice, it is calculated in the brewery that 1 bushel of malt in a brewing may be replaced, so far as available extract is concerned, by:

27½ pounds flaked corn.
26½ pounds rice.
26½ pounds grape sugar, or glucose.
29 pounds corn grits.

The hops used in beer brewing are the female flowers of the plant *Humulus lupulus.* The male flower is useless and the plant bearing it is never cultivated.

Average good, fresh hops are made up of from 7 to 10 per cent. of water; about 3 per cent. of tannin; some 10 per cent. of various mineral salts; 15 per cent. of albuminous

matter, of which one-half is coagulable by heat and made insoluble by the tannin; and about 10 per cent. of resins and essential oils and fats. These quantities, however, are by no means constant, and are found to vary as the hop grows older.

The tannin of the normal hop is entirely different, of course, from any other kind of tannin; and, in fact, appears to consist of two distinct varieties, one of which forms insoluble coagulates with albuminous bodies and yields a very pale green color when treated with ferric chloride, while the other is supposed to form compounds with albuminoids which are soluble in warm, but insoluble in cold liquids, and this variety produces a dark green color with ferric chloride. The value of these tannins is assumed to be confined, in the brewing process, to the formation of insoluble bodies from the coagulable compounds contained in malt wort.

As to the resins which are contained in the hop, they have been found to consist of three distinct physical varieties, but the individual qualities of each have not been thoroughly investigated and are very much in doubt. There is one of them which has a crystalline fracture and which, while it is quite tasteless in the solid form, becomes intensely bitter when dissolved in very dilute alcohol; but as a matter of fact, they are all three but slightly soluble in hot water, and appear to be thrown out of solution directly the water becomes cold. It has been stated by some investigators that all the preservative qualities of the hop are due to the resins, but I have found in my own practice that there are some ferments, and notably the acetic ferment, upon the growth of which the hops have no retarding action.

About one-half of the nitrogenous matter contained in hops does not coagulate when boiled, but goes into permanent solution in the boiling wort. This soluble hop albumen is easily assimilated by yeast and the plant thrives upon it perfectly. As you may very readily imagine, hops constantly vary in quality, in accordance with the climatic conditions of the year in which they are grown and picked. The chemist must, therefore, content himself, when a sam-

ple is submitted to him, with reporting upon the percentages of water and tannin, the condition and quantity of the lupulin, and the amount of extract yielded to petroleum ether, chloroform and water. If all these points compare favorably with established standards the sample in question may be expected to give good results in the brewery. No chemist can say, however, whether the hop is going to impart the desired aroma, or foretell whether it will or will not give some characteristic and undesirable flavor. When hops are quite fresh, we find the lupulin in the form of golden yellow globules filled with an almost colorless liquid. It becomes gradually darker with age, until it is finally brown. This transformation is invariably accompanied by a reduction in the percentage of the tannin, and by the production of valerianic acid, the disgusting smell of which enables its presence to be readily detected.

Having thus taken a bird's-eye view of the materials used by the modern brewer, it becomes necessary for me to acquaint you with those organisms or plants which induce alcoholic fermentation in saccharine solutions, and which are known under the general name of *Saccharomyces.* Under normal conditions they reproduce themselves by budding, and they have been therefore assigned to that division of the great fungus group known as budding fungi. In brewing technology they are described under the general term *Yeast.* Yeast cells are either single or occur in groups or strings; each cell consists of a thin-walled sac or bag, containing a semi-fluid matter, in the center of which there is often a space full of a more clear and watery fluid than the rest, which is termed a vacuole. The sac is comparatively tough, but it may be easily burst, when it gives exit to its contents, which readily diffuse themselves through the surrounding fluid. The whole structure is called a cell, the sac being the cell wall and the contents the protoplasm. Under a high magnifying power each cell is seen to be round or oval, and on the average about $\frac{1}{3000}$ of an inch in diameter. To the naked eye yeast appears as a thick, cream-colored fluid. If all the liquid be removed from the mass by pressure, the residue may be dried at a low temperature to a

powdery mass, without losing its vitality. When heated in the moist state to the temperature of boiling water, its fermentative power is completely destroyed. Fermentation which has already commenced in a liquid can be stopped by boiling it.

There are found to be associated with ordinary yeast in most fermentations and beers a great number of organisms of quite different appearance and character from the true beer yeast cells, and which may all be classed under the general terms wild yeast and bacteria. Chemists have proved most conclusively that these organisms give rise to the various diseases to which beer is subject. In other words, they induce fermentations in saccharine solutions which give rise to other products than alcohol and carbonic acid, and this has led to their classification according to the functions they fulfil or the products they engender.

When a minute quantity of pure beer yeast is added to some brewers' wort which has previously been filtered bright, the mixture, if kept in a glass flask at a temperature of about 70° F., soon becomes turbid and after a few hours gives off bubbles of gas which rise to the surface, the liquid becoming gradually more and more turbid. Later on, a sediment of yeast will be observed at the bottom of the flask. If the yeast cells be carefully examined under the microscope from time to time while this action is going on it will be noticed that at first the vacuoles which were present in every cell gradually disappear, each cell becoming full and rounded in appearance, owing to the absorption through the cell walls of certain nourishing substances from the wort. Some minute little buds will be noticed jutting out from the sides of the cells; these buds rapidly grow and soon assume the size of the parent cell, from which they finally become detached, but not before they, in their turn, have developed other buds, and these yet others, thus giving rise to those groups or strings of cells which are sometimes seen under the microscope. This cell reproduction and growth is due to the nourishment which the yeast derives from the wort, but for some time after the yeast cells continue to produce buds—and even after the

rupture takes place between the parent cells and the resulting daughter cells—the former still continue to absorb and assimilate various nitrogenous substances from the liquid.

It was long held that the only true theory in regard to fermentation was the one formulated by the distinguished Pasteur, which was, that:

"Alcoholic fermentation is a chemical action connected with the vegetable life of cells, which cells, in the absence of free oxygen, live by withdrawing the oxygen they require from certain carbohydrates, such, for example, as maltose or grape sugar."

Quite recently, however (1897), it has been shown by Buchner—a good authority—that the actual process of fermentation, or, in other words, the decomposition of sugar into alcohol and carbonic acid gas, is independent of the vital action, being induced *outside the yeast cells by a functional product excreted during its growth.* This product has been eliminated by Buchner and called zymase; and it is to all intents and purposes an enzyme or diastase.

[*To be concluded.*]

Mining and Metallurgical Section.

Special Meeting held Wednesday, January 31, 1900.

THE OCCURRENCE OF FULLER'S EARTH IN THE UNITED STATES.

BY DR. DAVID T. DAY,
Chief of Division of Mineral Resources, U. S. Geological Survey.

Characteristics.—The only classification of clays which suggests itself by which definite place can be given to the variety called fuller's earth would be based upon the consideration of the relative proportion of total bases, such as alumina, iron, calcium, magnesia, alkalies and silica, together with the proportion of water in the sun-dried clay. Very frequently the clays which have a large proportion of total

bases and silica usually contain more than the average amount of water. For example, kaolin, containing from 40 to 50 per cent. of silica, and from 30 to 40 per cent. of total bases, will frequently contain from 10 to 15 per cent. of water in the sun-dried material. Where, however, the percentage of silica is very high, say 70 per cent., and the total percentage of bases less than 30, the percentage of water is usually quite low. Fuller's earth appears to be an interesting exception to this rule, as its chief chemical characteristic seems to be a high percentage of silica, which, though varying through a considerable range, frequently reaches 65 to 70 per cent., but with a total proportion of bases even as low as 20 per cent., and seldom higher than 28 per cent., while the percentage of water in the sun-dried material will range easily from 15 to 25 per cent. Approximately half of this water can be driven off by prolonged heating in a water-bath; the remainder is only to be driven off at a much higher temperature. These clays usually stick to the tongue more than other clays. When placed in water they show no plasticity, but fall apart in gelatinous flakes.

Such clays have been used for very many years even in this country for extracting from newly-made cloth the oil used to render the wool pliable in weaving. From this fulling process the clay has taken its name.

Silliman refers* to a deposit near the town of Kent on the Housatonic River, in Connecticut. He states that: "A fuller's earth is a clay usually soapy in its feel, very absorbent of grease and oily matters; fine in its texture, so as to present no parts that shall be large and harsh enough to injure cloth or wool, mechanically, by rubbing; it should fall to powder easily in water, so as to diffuse itself through that fluid, and easily mix with it and with the stuffs to which it is applied. The fuller's earth of Hampshire, England, so much celebrated, is of a greenish-yellow, tolerably firm, crumbles easily in water, receives a polish from the finger nail, and is *very powerfully detergent*. This is, after

* *American Journal of Science*, first series, I, **2**, 217.

all, the important criterion by which to distinguish fuller's earth: if it removes grease with avidity, crumbles easily in water so as to diffuse itself readily, and yet is not so coarse as to wear the fiber, it is fuller's earth. The subject is of some practical importance to this country on account of its woollen manufactures, which, although checked for the present, must eventually rise and prevail. While they are of small extent it may be better to use soap, but in very large establishments fuller's earth from its cheapness (provided it can be abundantly obtained) is very desirable.

"With respect to the existence of fuller's earth in the clay of the Kent iron bed it appears very probable, and some of the specimens appear very like the Hampshire earth, but experiments alone can decide."

This visit of Silliman was in 1820. William Thompson* found clay in a fullonica excavated at Pompeii, which was pointed out to him as the soap which the ancient inhabitants used. This was used not only by the washers and dyers, but frequently in the ordinary houses. In composition it has the general characteristics of fuller's earth.

One of the first uses for the white kaolin at Woodbridge, N. J., was for this same purpose of fulling cloth in the absence of real fuller's earth, as shown by note on page 1 of the Report on the Clay Deposits of New Jersey, Geological Survey of New Jersey, in 1878.

But the name fuller's earth has usually designated the material obtained in Surrey, England. This has been the chief source of supply for English cloth manufacturers and for export. Various attempts have been made by mineralogists to find in fuller's earth some definite mineral substance which could be referred to as distinctive and which could be found in all varieties. Thus, Dana speaks of it as being in part kaolin and partly the hydrous silicate smectite, but this has been of little value in the identification of other specimens. Even to-day the name fuller's earth is applied to any form of clay which has the characteristics

* Reports of the British Association for the Advancement of Science, **49**, 321.

mentioned above, and is capable of absorbing liquids in considerable quantity, and particularly when it will act like bone-black in taking out the coloring matter from certain oils.

Developments of the Industry in the United States.—For many years either soap or fuller's earth was used as a detergent in fulling cloth, but with the increased use of cotton-seed oil English fuller's earth came to be used to decolorize such vegetable oils and also lard oils. This increased the importation of fuller's earth very markedly, as shown in the table appended.

In 1893 good fuller's earth was discovered in the United States quite accidentally. At Quincy, Fla., an effort was made to burn brick from the clay found on the lands of the Owl Cigar Company; the effort was a failure, for fuller's earth when burned exfoliates instead of forming a coherent mass, suitable for bricks. An Alsatian cigarmaker employed by the company called attention to the close resemblance of this clay to the German fuller's earth. As a result, the material found sale and the industry was developed. This use quickly spread as a substitute for, though more expensive than bone-black, filtering various mineral oils, and it is principally for such purposes that the American earth is now used, the English earth being preferred for cotton-seed and lard oils. The development of the industry in this country was sufficient to develop a widespread interest in the search for fuller's earth, and thousands of samples were examined by the chemists of various consumers. Most of the clays examined proved worthless, yet enough good samples were obtained to show that the region to the west and north of Quincy contained many other available deposits if needed. The search extended over the United States, and deposits were soon found in Virginia, North Carolina, Georgia, at various places in Florida, Indian Territory, Nebraska, Colorado, New Mexico and South Dakota. A small industry has been developed in New York State, but, with this exception, the supply continues to come from the developed deposits at Quincy, Fla. The reason for this is the great variation in quality of the earth

from different deposits. That from North Carolina and Virginia is more or less sandy; that from Georgia is almost identical with the Quincy earth, but is not more favorably located for shipment. All the other deposits are less accessible, except one near Tampa, which promises soon to be a large source of supply. Curiously enough, the material produced in Florida bears little outward resemblance to the earth which has long been imported from England.

The earth discovered in South Dakota is almost the exact duplicate of the English earth in every respect, and will no doubt become a valuable substitute for it.

Fragments of chert are common in beds of fuller's earth, and in Georgia fuller's earth passes almost indistinguishably into layers of chert, with nearly the same color and fracture. At Ballert Point, near Tampa, Fla., the fuller's earth contains many oyster shells, bits of coral, etc., all entirely changed to chalcedony. This leads to the suggestion, as to the origin of this earth, that it is probably ordinary clay which has received from interfiltering solutions an additional supply of silicic acid which has sometimes combined with the clay, and occasionally has been deposited as chert.

The conditions of occurrence of fuller's earth and the manner of preparing it for market are quite simple. In Florida it may be found outcropping at the foot of slopes around the edges of the swamps. The clays appear to occur in large, shallow basins in the swampy tracts characteristic of the region around Quincy, and many other parts of the State. Usually there will be 1 or 2 feet of surface soil, then 2 to 6 feet of mottled, plastic clay, then the fuller's earth in layers varying in thickness from 2 to 12 feet, then a layer of sand mixed with fuller's earth, which is usually persistent for a considerable depth below the deposit. Occasionally a second deposit of fuller's earth, bluish in color, will be found below the first, with a layer of sand intervening. Up to this time the very simplest methods have been used in preparing it. The overburden of sand and worthless plastic clay is removed and the wet fuller's earth chopped out in thin slices with mattocks and allowed to dry in the sun for several days. By this means the wet, greenish clay will lose

PRODUCTION OF FULLER'S EARTH IN THE UNITED STATES FROM 1895 TO 1898.

Year.	Quantity.	Value.
	Short Tons.	
1895	6,900	$41,400
1896	9,872	59,360
1897	17,113	112,272
1898	14,860	106,500

IMPORTS OF FULLER'S EARTH FROM 1867 TO 1899.[1]

Year.	All Kinds.		Unwrought.[2]		Wrought.[2]	
	Quantity. Tons.	Value.	Quantity. Tons.	Value.	Quantity. Tons.	Value.
Ending June 30th.						
1867	280	$3,113				
1868	211	2,522				
1869	324	3,587				
1870	239	2,619				
1871	290	3,383				
1872	274	3,358				
1873	251	2,978				
1874	277	3,440				
1875	300	3,694				
1876	246	3,097				
1877	400	4,460				
1878	335	4,095				
1879	361	4,269				
1880	578	6,925				
1881	268	3,207				
1882	908	11,444				
1883	1,241	14,309				
Ending December 31st.						
1897[3]	—	—	2,308	$14,283	2,138	$20,037
1898	—	—	2,038	15,921	6,315	55,123
1899[4]	—	—	2,639	17,147	5,243	37,525

[1] Not classified from 1883 to 1897.
[2] Not classified separately until 1897.
[3] Latter half.
[4] Three-quarters of calendar year.

	SiO_2.	Al_2O_3.	Fe_2O_3.	CaO.	MgO.	H_2O.	Na_2O.	K_2O.
	P. C.	P. C.	P. C.	P. C.	P. C.	P. C.	P. C.	P. C.
Smectite from Cilly[1]	51·21	12·25	2·07	2·13	4·89	27·89	—	—
Fuller's earth from Reigate[2]	53·00	10·00	9 75	·50	1·25	24·00	—	—
Malthite from Steindörfel[3] . .	50·17	10·66	3·15	·25	—	35·83	—	—
Fuller's earth from England[4]	44·00	11·00	10·00	5·00	2 00	—	5·00	—
Fuller's earth from England[5]	44·00	23·06	2·00	4·08	2·00	24·95	—	—
Fuller's earth from England, No. 1 (blue earth)	52·81	6·92	3·76	7·40	2·27	14·27	—	·74
Fuller's earth from England, No. 2 (yellow earth)	59·37	11·82	6·27	6·17	2·09	13·19	—	·84
Fuller's earth from Gadsden County, Fla.[6]	62·83	10·35	2·45	2·43	3·12	7·72	·20	·74
Fuller's earth from Decatur County, Ga.[6]	67·46	10·08	2·49	3·14	4·09	5·61	—	—
Fuller's earth from Fairburn, S. D.[7]	58 72	16·90	4·00	4·06	2·56	8·10	2·11	
Fuller's earth from southeast of River Junction, Fla.[8] . .	50·70	21·07	6·88	4·40	·30	9·60	—	—
Fuller's earth from between Mt. Pleasant and Norway, Fla.[9]	58·30	10 63	6·72	1·71	3·15	9·05	—	—
Fuller's earth from near Norway, Fla.[10]	54·60	10·99	6·61	6·00	3·00	10·30	—	—
Fuller's earth from Valentine, Neb.	47·37	7·08	3·89	32·19	1·19	—	Trace	·38
Fuller's earth from Ocala, Fla.	36·73	27·78	3·21	·81	·64	At 110°, 7·38 Above 110°, 12·14	—	·42
Fuller's earth from Fairburn, S. D.	68·23	14·93	3·15	2·93	·875	6·20	—	—
Fuller's earth from Custer, S. D.	55·45	18·58	3·82	3·40	3·50	8·80	—	—
Fuller's earth from Custer, S. D.	57·00	17·368	2 362	3·00	3·027	9·50	—	—
Fuller's earth from Custer, S. D.	63·50	14·97	4·48	2·40	2·882	—	7·20	1·116
Fuller's earth from Custer, S. D.	71·28	14·33	2·484	·33	1·199	4·30	—	—
Fuller's earth from Hermosa, S. D.	55·40	27·70	1·80	2·30	·703	—	·487	·589
Fuller's earth from Fairburn, S. D.	60·16	10·38	14·868	4·96	1·714	7·20	—	—
Fuller's earth from Fairburn, S. D. (dried)	56·18	23·23	1·26	5·88	3 29	11·45	—	—
Fuller's earth from Fairburn, S. D.	67 00	5·00	12 00	—	—	15·00	—	—
So-called "Glacialite," Enid, Oklahoma Ter.	50·36	33·38	3·31	—	—	12·05	·88	

[1] Pogg. Ann., 77, 591, 1849.
[2] Klaproth, Beitr., 4, 338, 1807.
[3] Dana, System of Min., p. 695, 1893.
[4] Geikie, 1893, p. 133.
[5] Penny Encyclopedia, 11, Dr. Thompson, analyst.
[6] P. Fireman, analyst.

SO_3.	CO_2.	P_2O_5.	FeO.	TiO_2.	NaCl.	MnO.	Moisture.	Volatile Matter.	Organic Matter.[11]	Moisture in Air-Dried Sample.	Calculated to Water-Free Material (dried).
P. C.	P. C.	P. C.	P. C.	P. C.	P. C.	P. C.	P. C.	P. C.	P. C.	P. C.	P. C.
—	—	—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—	—	—
·05	—	·27	—	—	·65	—	—	—	—	—	—
·07	—	·14	—	—	·14	—	—	—	—	—	—
—	—	—	—	—	—	—	6·41	—	—	—	—
—	—	—	—	—	—	—	6·28	—	—	—	—
—	—	—	—	—	—	—	2·30	—	—	—	—
—	—	—	—	—	—	—	7·90	—	—	—	—
—	—	—	—	—	—	—	9·55	—	—	—	—
—	—	—	—	—	—	—	7·45	—	—	—	—
·20	17·73	·21	—	—	—	—	—	—	—	2·53	110 C.
—	—	5·54	—	1·37	—	—	—	—	3·61	—	—
—	—	—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	Trace	—	5·35	—	—	—
—	—	—	—	—	—	Trace	—	5·85	—	—	—
—	—	—	—	—	—	—	—	CO_2 & Vol. 10·70	—	—	—
—	—	—	—	—	—	Loss	—	Alk. und.	—	—	—
—	—	—	—	—	—	13·00	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	Org. Trace	—	TiO_2 Trace	—	—	—

[7] E. J. Riederer, analyst.
[8] Standard Oil Company's property. E. J. Riederer, analyst.
[9] Howell property. E. J. Riederer, analyst.
[10] Morgan property. E. J. Riederer, analyst.
[11] The organic matter is based on the assumption of Wolff that humus contains 58 per cent. carbon, the latter being directly determined.

perhaps 50 per cent. of its weight, turn to a creamy white color and become very brittle and easily split into thin layers. It then contains 15 per cent. of its weight of water, which can only be driven off above the boiling point. Lately artificial dryers have been introduced and an arrangement for grinding the earth to the requisite fineness. The process of levigating the earth, which is quite common in Surrey, England, is not used in this country at all. This Florida earth, ground to 60 mesh and finer, is used almost entirely as a substitute for bone-black in filtering mineral lubricating oils, although its use has extended to some extent for the lightening of the color of cotton-seed oil. But for this latter purpose the practice is still universal of using English fuller's earth which has been taken out by the ordinary method and then washed in long, narrow troughs, very much like hydraulic sluice boxes, allowing quite a large percentage of the material to settle out as sand and displace the lighter material which goes off into the settling tanks, in which it is finally dried and sold in the resulting lump form. The English earth has not proved any more suitable for the refining of mineral oils than has the American earth for use in vegetable oils. The common practice with the mineral oils is to dry the earth carefully after it has been ground to 60 mesh, and fill it into long cylinders, through which the crude black mineral oils are allowed to percolate very slowly. As a result the oil which comes out first is perfectly water-white in color and markedly thinner than that which follows. The oil is allowed to continue percolating through the fuller's earth until the color reaches a certain maximum shade, when the process is stopped, to be continued with a new portion of earth. The oil is recovered from the spent earth.

With the vegetable oils the process is radically different. The oil is heated to beyond the boiling point of water, in large tanks, to which from 5 per cent. to 10 per cent. of its weight of fuller's earth is then added, and the mixture vigorously stirred for twenty minutes and then filtered off through bag filters. The coloring matter remains with the earth, leaving oil of a very pale straw color, provided the

original cotton-seed oil had been sufficiently well refined by the ordinary process to admit of this, and provided the operation had been conducted with sufficient care. Perhaps the most remarkable feature of this filtration by fuller's earth is the different rate of speed at which oils of different density, in such a mixture of oils as is found in an ordinary crude petroleum, will percolate through, with the result that the first oil which makes its appearance is not only very much lighter in color, but markedly lower in specific gravity. In fact, by this process separations can be made which are quite comparable with the results of fractional distillation. There is no question but that a method is here suggested for the scientific investigation of petroleum which chemists will not be slow to utilize, and, while it is slower and not so sharp in the fractions yielded, it is perfectly evident that the oil undergoes little change due to the process of separation itself, as is almost always found to be the case in fractional distillation.

Stated Meeting, held Wednesday, December 13, 1899.

THE TILLY FOSTER MINE.

BY EDWARD K. LANDIS.

This celebrated mine is situated in Putnam County, N. Y., about 52 miles north of New York City and 2 miles west of Brewster, where the Harlem and New York and New England Railroads cross each other. Brewster is also the northern terminus of the New York City & Northern R. R., since absorbed by the Harlem. This latter railroad runs through the mine property, so that the shipping facilities are exceptionally good.

HISTORY.

In 1697, William III granted Adolph Philipse a tract of land, now Putnam County, N. Y. At his death it came to his nephew, Frederick, and in 1754 Frederick's three surviv-

ing children divided the surface equally between them, but reserved the mineral rights in common. From this it would seem that the existence of valuable deposits of iron ore in Putnam County was known at this early period, but it is only since 1879 that this county has become a prominent iron producer. Desultory mining had been carried on before that time at the Sump, Croft and Tilly Foster mines, but the output was limited.

Geologically the occurrence of the ore is similar to that of the New Jersey and Lake Champlain magnetites, the country rock and physical geography being identical. The strike is N. 40°, E. and dip 66°; 66° S., 50° E.

The deposit is undoubtedly a bed. At the edges of the bed the foot and hanging walls meet, but do not coalesce, the plane of contact being distinctly marked. The two walls are separated by 3 to 6 feet of clay or gouge, which sometimes diminishes to a few inches. At the southwest end of the 300-foot level this gouge or parting was followed for a distance of 120 feet in hopes of finding another body of ore, but in vain. In the southwest end the ore is coarse-granular and coarsely crystalline, while in the northeast end it is fine-grained and finely crystalline.

In the upheavals and dislocations which were predominant features of this geological period, the strata of gneiss containing this bed of magnetite were changed from a horizontal to a vertical position, and even overturned beyond the vertical, having moved through 114°, and now dip 66° southeast. A series of vertical sections of the deposit shows the marked convexity of the hanging wall and concavity of the foot wall, from which it may be inferred that what is now the hanging wall was, before the upheaval, the bottom of the deposit.

METHOD OF MINING.

A main incline was sunk on dip of foot wall and stations cut every 100 feet, then a wide drift was run along the foot wall to the ends of the ore body. From this drift, rooms 24 feet wide with intervening 20-foot pillars of ore were turned towards the hanging wall. Each room was raised to within

15 feet to 20 feet of the one above. Enough ore was left for the miners to reach the solid stope above and only the surplus withdrawn from day to day. When the room had been stoped out all loose ore was removed and the room abandoned. All material broken was hoisted to the surface, dumped into cars and sorted. Waste usually exceeded 25 per cent. It was estimated that this method left over half the ore in pillars and floors, and in September, 1884, it was calculated that over 1,000,000 tons of ore was thus developed and in sight. At that time masonry pillars were built extending clear across the vein on the 300-foot level at three different points, about 40 feet apart, and carried up nearly 100 feet. These pillars were about 20 feet wide and were intended to take the thrust of the overlying mass, and allow the ore pillars to be robbed from between them, but the roof was not solid enough to permit this and finally the entire roof was removed and the mine worked as an open cut. This was the only method of winning the remainder of the ore, as under previous methods it was impossible to continue the operation of the mine, owing to the many accidents from falls of roof, etc. One "cave" rendered the mine unprofitable for two years.

The amount of ore mined cannot be ascertained, but through the courtesy of Mr. S. P. Tomkins, superintendent, the following figures are given:

	Tons.	
Ore mined from 1879 to 1888	335,059,	Old method.
Ore mined from 1888 to 1897	499,242,	New "
Ore shipped in 1899 (in stock)	59,679,	" "
	893,980	

The concentrating mill has shipped to date 57,977 tons of concentrated ore running 50 per cent. metallic iron and made from lean ore averaging about 28–30 per cent. metallic iron.

The total shipments of ore and concentrates from 1879 to 1899 were 951,957 tons, of which amount 616,898 tons were shipped after the adoption of the open-cut method, and could not have been won otherwise. The superintendent,

Mr. Tomkins, informs me that the ore is now stripped to a point about 430 feet from the surface, and the ore in sight and recoverable is estimated at 250,000 to 300,000 tons.

The concentrating mill has a capacity for crushing 400 tons per day of ten hours, and the two Ball steam stamps will stamp 180 tons in the same time. As 5½ tons of lean ore are required to yield 1 ton of concentrates, the mill could turn out from 60 to 70 tons of concentrates per day.

METHOD OF MEASUREMENT.

Devised by C. C. Mattes, C.E.

The mine was divided into 10-foot squares and lines marked by stakes set well back from edge of pit. A wire rope about ¼ inch to ⅜ inch stretched over a longitudinal line and trolley carrying steel tape and plumb-bob traversed along it. Level set up in north end, and H.I. determined from some convenient bench. Plumb-bob dropped to bottom and tape read, then tape wound up until plumb-bob was on crosshair of level, and tape read again. The results of these measurements were plotted on cross-section paper, and the volume excavated between the monthly measurements was calculated, the areas on the cross-sections being measured by a planimeter. This method permitted the accurate measurement of inaccessible places, and by its use a complete survey of the mine could be made in three days' time, only requiring the services of two civil engineers (one for the iron company and the other for the contractor), one levelman, and two laborers. The contractor was paid for both rock and ore on a scale varying according to the level of the material, and when a considerable depth had been reached, if a piece slid down the hanging wall from some point that could not be reached from above or below, the monthly measurement would show the original level of the material, and the contractor was paid accordingly.

On the ANNEALING of WHITE CAST IRON.

By Charles James,
Member of the Institute.

The paper on the annealing of white cast iron, which I have to present to you this evening, is not based upon laboratory experiments, but is an abstract of results obtained from daily business practice, extending over a considerable period of time. But, though these investigations were made for the guidance of commercial operations, they seemed to be of sufficient metallurgical interest to justify their presentation to you this evening.

The irons used in these operations were all of Bessemer quality, smelted with coke, no charcoal or other special iron being used. The melting furnace charges consisted of a mixture of gray and white irons, of which the following is an average analysis:

	C.C.	G.C.	Si.	Mn.	S.	P.
White iron . . .	3·50	·50	·50	·20	·08	·08
Gray iron . . .	·50	3·50	1·30	·30	·02	·03

The charges varying from 15 per cent. to 25 per cent. white iron, from 50 per cent. to 60 per cent. gray iron, and from 20 to 30 per cent. scrap iron from previous meltings. The variations being made in accordance with the variations in the components of the pig iron and the description of casting required.

The composition of the charges was regulated by the silicon content, which was made to vary from 1·20 to ·90 of 1 per cent.

The higher percentages of silicon being employed when very hot and very fluid metal was required.

The average chemical composition of these mixtures being:

	Per Cent.
Carbon	3·40 to 3·80
Silicon	·90 to 1·20
Manganese	·35 to ·20
Sulphur	·05 to ·04
Phosphorus	·04 to ·03

The iron was sometimes smelted in a cupola, but generally in an air furnace. The air-furnace charges were from 3 to 5 tons, and the furnace pre-heated to nearly a melting temperature before introducing the charge. The time occupied in melting was usually from three and one-quarter to three and three-quarters hours. As soon as the charge had completely melted, the bath was well rabbled, to obtain as complete a mixture as possible. Test pieces 8 inches long and 1¼ inches in diameter were then taken, and as soon as the iron had solidified the test pieces were rapidly cooled and broken. They usually showed a gray or highly mottled fracture, and the subsequent operations were conducted accordingly. The fining and final heating of the metal generally occupied from thirty to forty-five minutes, and was continued until a similar test piece was obtained free from all traces of gray iron. The casting made from such iron, however, frequently contains some graphite, due possibly to the different condition of cooling: but this graphite rarely exceeded one-half of 1 per cent., as the following analysis, which is an average from a large number of such castings, will show:

C.C. . 3·02 G.C. . ·47 Si . ·78 Mn . ·120 S . ·05 P . ·04

The annealing-furnace charges varied from 2 to 3 tons, the castings being placed either in the open furnace and the flame and furnace gases allowed to pass uninterruptedly over and between them, or packed in covered boxes of cast or wrought iron. No difference in the results, except as to scale, was to be observed or detected by either chemical analysis or physical tests, provided the heat treatment was conducted so as to compensate for the changed conditions. Castings packed in boxes, being practically solids of the same dimensions as the boxes, require a longer time to attain the same heat condition throughout their mass than do individual castings treated in the open furnace. But, as castings packed in boxes retain their heat for a greater length of time, and as the annealing effect continues for some time after the mass begins to cool, the total time required for either operation is nearly the same.

The weight of the various castings treated ranged from half (½) an ounce to 2,000 pounds and over. The time required to effect the carbon change—to be hereafter described—varied from three and one-half to ten hours, from the time the castings had attained their full temperature. The temperature at which the carbon change takes place in castings of this description lies between the melting points of silver and copper, and may, therefore, be approximately taken as 1,850° F.

The change in the condition of the carbon, in irons of different composition, occurs at different temperatures. The range of temperature, however, at which the changes take place in different irons is not very great, and is always closely related to and governed by the temperature of their solidification, and this temperature in turn is largely governed by the relative amounts of carbon, silicon, manganese and sulphur contained in the iron.

For irons of similar composition, the length of time required to complete the annealing effect in any casting depends upon the section area of that casting.

Thus, of two castings of similar chemical composition before annealing, but of different sectional areas, the one weighing 53 and the other 1,890 pounds, the smaller casting, after three and one-half hours' annealing, had the following chemical composition:

C.C. . . . ·61 G.C. . . . 2·83

and the larger casting, after seven and one-half hours' annealing, gave:

C.C. . . . 1·65 G.C. . . . 1·85

This casting had to be returned to the furnace and subjected to a further annealing of three and one-half hours' duration, after which it approximated closely in chemical composition to the smaller casting.

The change of carbon in castings subjected to the annealing process, though gradual, is co-extensive throughout any given cross-section of the casting; no hard center or core of white iron, surrounded by softer metal, having ever been observed in any of the castings examined. No matter at

what period the annealing process may have been arrested, the total surface of any fracture always showed a similarity in the condition of the metal, provided the composition of the metal was homogeneous, and the heat treatment had been applied equally to all parts of the casting.

We will now consider the nature of the change or changes that occur in the casting during annealing, and to enable us to do this we will take the analysis of an average casting produced by this process, both before and after annealing:

Before annealing .	C.C.,	2·60	G.C.,	·72	Si,	·71	Mn,	·110	S, ·045 P, ·039
After " .	"	·82	"	2·75	"	·73	"	·108	" ·04 " ·039

From these analyses it will at once be seen that the only change effected is one of condition in the carbon, a large proportion of which has passed from the combined into the graphite state. I wish, however, to say that, though for convenience the term graphite is employed in stating the analyses of these castings after annealing, the condition of the carbon—as I shall presently show—differs very materially from graphite, either as found free in nature or as solidified out from gray iron during cooling.

It has already been shown that the relative quantity of combined and graphitic carbon found in any specimen of iron after annealing depends upon the heat treatment it has received in relation to its chemical composition and sectional area. And it now remains to inquire what effect the other components of the iron exert upon the carbon change. This question has been directly investigated only so far as silicon, manganese and phosphorus are concerned. And of these phosphorus can at once be dismissed with the remark that, in all cases, it was found to be inoperative, at least in the small amount in which it was present in these castings.

With respect to sulphur, the investigations are not yet completed, but are still in progress, and, at a future date, I may be able to lay before the Section some data respecting its influence.

Both silicon and manganese exert great influence upon the carbon during the annealing process, the presence of

silicon being a necessary condition to the carbon change. In low silicon irons it is very difficult, and, in some cases, impossible, to effect the carbon change no matter how long the iron is exposed to the heat treatment. This fact is strikingly illustrated in the following example:

A casting about $\frac{5}{16}$ inch in thickness and weighing less than one pound, and of the following composition:

C.C. . . . 2·08 G.C. . . . none Si . . . ·42 Mn . . . ·05

was subjected to the usual treatment, but after being annealed for three and one-half hours the casting was still hard, and had a white iron fracture, and analyzed

C.C. . . . 1·97 G.C. . . . none

After a second annealing of three and one-half hours the appearance of the casting was still unaltered, and the analyses gave:

C.C. . . . 1·98 G.C. . . . trace

Subjected to a third annealing of three and one-half hours the casting was still hard and had a white iron fracture, and analyzed

C.C. . . . 1·90 G.C. . . . ·14

Thus, after being exposed for ten and one-half hours to the full annealing temperature, as well as passing three times through the much longer period of heating and cooling, only ·14 of 1 per cent. of the combined carbon had been changed to the graphite state.

In the example just given, both carbon and manganese, as well as the silicon, are comparatively of low percentage.

In the following instance, however, the carbon and manganese are both of fairly high percentage, but the casting, after repeated annealings, analyzed

C.C. . . 1·76 G.C. . . . 1·08 Si . . . ·31 Mn . . . ·126

and the iron remained hard and white, and could not be machined.

Indeed, the relative amount of carbon that can be changed from the combined to the graphite state during annealing

seems to be directly proportionate to the amount of silicon present, as indicated by the following example, in which all three samples were taken from the same cast, annealed in the same furnace at the same time and under identical conditions:

No. 1—C.C. . .	1·49	G.C. . .	1·40	Si . . ·56	Mn . . ·126
No. 2—C.C. . .	1·57	G.C. . .	1·33	Si . . ·45	Mn . . ·130
No. 3—C.C. . .	1·87	G.C. . .	1·03	Si . . ·31	Mn . . ·126

In this instance the total carbon and the manganese are practically the same in all three examples, and of comparatively high percentage, the silicon being the only varient, except the condition of the carbon, which is less and less changed as the silicon in the iron decreases.

That low carbon, or at least comparatively low carbon, does not prevent the change in the carbon condition taking place seems well illustrated in the following example of a comparatively low carbon iron subjected to three and one-half hours' annealing:

Before annealing	. C.C. . 1·94	G.C. . none	Si . ·64	Mn . ·09
After "	. C.C. . none	G.C. . 2·00	Si . ·62	Mn ·110

In this instance the percentage of silicon is slightly under the normal amount usually present in this class of castings, while the manganese is well up to its average in such castings.

The influence of the manganese on the carbon change is not nearly so marked as that of silicon, and its action is further obscured by the high silicon which always accompanies high manganese, for, as the percentage of manganese rises in the casting, the percentage of silicon rises also. Comparatively high manganese, however, assists the carbon change and shortens the time necessary for its completion. This is illustrated in the following analyses of a high manganese casting after being annealed for three hours only:

Before annealing	. C.C. . 3·68	G.C. . none	Si . ·93	Mn . ·30
After "	. C.C. . none	G.C. . 3·62	Si . ·95	Mn . ·31

In this instance the casting showed signs of overannealing, and the process had evidently been carried on much longer than was necessary.

The action of silicon and of manganese upon the carbon change is apparently of an essentially different character, that of silicon being direct upon the carbon, compelling it to change its condition, while the influence of the manganese is only indirectly upon the carbon through the silicon by protecting the latter from oxidation during the melting of the iron, thus causing the percentage of the silicon in the casting to be higher than it would be if the manganese had itself been more completely oxidized from the bath. This also accounts for the fact that comparatively high silicon and comparatively high manganese and the reverse are always coincident.

In every case, however, irons low in silicon and manganese are practically worthless after annealing. Such irons may be softened by the process, so as to machine easily, but are always deficient in tenacity. They generally have a white fracture, in appearance like that of a 30 per cent. carbon Bessemer steel bar. The analyses, after annealing, of two such irons are given for comparison:

No. 1—C.C. . . 2·65	G.C. . . none	Si . . ·46	Mn . . trace
No. 2—C.C. . . 1·97	G.C. . . none	Si . . ·42	Mn . . none

The analysis shows that there was no change of the carbon conditions during annealing. The samples machined easily, but broke to pieces under the pressure of the lathe tool.

That this change of carbon, from the combined to the graphite condition, can be produced by this method of annealing in other combinations of iron and carbon, as well as in white iron castings, is proved by the following experiment carried out upon a hammered bar of crucible tool steel, which analyzed before annealing:

C.C. . . ·97	G.C. . . none	Si . . ·32	Mn . . ·31

After four hours of annealing, the sample exhibited only the appearance of well-annealed tool steel, except that a skin of bright iron, similar to that seen around some malleable iron casting, had appeared. After a second annealing for four hours, the bright skin had deepened into the bar, and the remaining portion of the cross-section had a leady

appearance. After a third annealing of four hours, the bright skin had increased still more in depth, and the remaining portion of the cross-section had become black with graphite carbon, some bright spots, however, still being visible. The bar then analyzed:

C.C. . . ·47 G.C. . . ·42 Si . . ·38 Mn . . ·30

showing that nearly 50 per cent. of the carbon had changed its condition, the loss of carbon shown by this analysis being due to the decarbonizing of the surface of the bar.

Lastly we have to consider the nature of the carbon found in the castings after annealing. The carbon thus formed is evidently identical with what Ledebur has called "tempering graphite carbon," and is an allotropic form of graphite, and not merely amorphous carbon, since I find, by experiment, that it differs from both these varieties of carbon in its specific gravity, specific heat and calorific power, which after careful examination I find to be as follows:

Specific gravity	1·9 as compared to water.
Specific heat	·2237
Calorific power	7893 heat units.

That this allotropic form of graphite should have been mistaken for a graphite similar to that of gray cast iron, though it has none of the bright scaly luster of the latter, is not surprising, since it can be both separated from the iron, and chemically determined in the same manner as the graphite, from gray iron, though its combustion is much more difficult.

The chemical and physical condition attending the formation of this allotropic graphite during the annealing process, and its probable molecular form, as well as the position it occupies in the structure of the casting, which differs so remarkably from the position occupied by graphite in gray iron, have already been described in a paper read by me before this Section in 1897. And I need not now refer to this part of the subject, further than to say that the change, as at that time pointed out, affords a striking example of the solution of one solid in another, at temperatures below the melting point of either.

Contrary to Ledebur's statement, that "tempering graphite carbon" is unaffected by the hardening process, I find that iron containing this allotropic graphite hardens and tempers excellently well, and that when not fully developed by over-long annealing, the whole of this carbon will pass into the hardening state and leave the iron without a trace of free carbon.

I also find that, by prolonged heating, this allotropic form of graphite becomes changed to graphite identical with that found in gray iron, and that it then occupies a similar position in the iron structure, and greatly injures its physical qualities, so that overannealing should at all times be carefully avoided.

Photographic and Microscopic Section.

Stated Meeting, held Thursday, May 3, 1900.

NOTES ON GOLD-SODIUM CHLORIDE.

By Lyman F. Kebler.

If any one will take the trouble to obtain quotations from the various manufacturers, or consult their price lists, it will become apparent at once that there must be either a considerable margin of profit for some, or that the gold-sodium chloride varies much in composition. The difference in prices, or information on the labels are such, however, that the various makes come into direct competition with one another. For example, 1 ounce of gold-sodium chloride, U.S.P., in ⅛-ounce vials, is quoted by several makers (wholesale price list) at $5.90, $6.10, $7.50, $9.60 and $14.50, respectively. Again, some makes, without any specifications as to quality, are generally quoted a few cents below those containing information as to quality.

It must be remembered that the 1890 Pharmacopœia requires this article to contain 30 per cent. of metallic gold, and a commercial article may contain less for photographic

purposes, but the latter should be so labelled as not to be brought into direct competition with the more costly article. If a certain article is prepared for photographic purposes or for some other purpose, let it be so labelled as not to be misleading.

In order to get positive information about this article the writer secured a number of samples, and a careful examination of the same gave the following results:

ANALYTICAL DATA OF GOLD-SODIUM CHLORIDE.

Number.	Condition.	Reaction to Ammonia on Glass Rod.	Reaction to Litmus.	Weight in Grains in 15-gr. Vial.	Solution Containing 15 gr. in 100 c.c. Dist. Water.	Marks on Labels.	Actual Per Cent. of Metallic Gold Gravim.	Per Cent. of Gold Based on 15 Grains Gravim.
1	Quite moist	None	Acid	13.55	Slightly opalescent	15 grains	23.55	21.29
2	Dry	"	"	14.42	Clear	15 grains	27.22	26.13
3	Dry	"	"	14.86	Slightly opalescent	15 grains	25.00	24.68
4	Dry	"	"	17.53	Clear	15 grains U.S.P.	28.31	32.91
5	Slightly moist	"	"	14.45	Clear	15 grains U.S.P.	30.30	29.02

The amount of material contained in each vial was estimated by removing the stopple, determining the gross weight, then carefully removing the chemical by means of water, drying the vial and obtaining its weight. From these weights the amounts of gold-sodium chloride in each vial can readily be calculated, and if there should be an error in any direction, it is quite likely to be in favor of the chemical.

The metallic gold was estimated as follows: Transfer the contents of a vial into a 250 cubic centimeter evaporating dish, by means of 100 cubic centimeters of a 1 per cent. solution of pure sulphuric acid. In this mixture dissolve 2 grains of pure oxalic acid, then place the whole on a steam-bath for two hours, or until all the gold is reduced to the metallic state. Decant the clear liquid as closely as possible, wash the gold with distilled water, dry, ignite and weigh. This method works well, but the volumetric process for this purpose appeared to be valueless.

From a careful perusal of the data contained in the foregoing table, it can readily be seen that all the samples were of good quality, but there is a wide variation in the percentage content of gold.

In order to fully comprehend the actual difference in money value existing between the various samples, it is only necessary to compare the figures below:

Number.	100 Ounces Gold-Sodium Chloride Contained Pure Gold.	Cost at $21 Per Ounce.
1	21.29	$447 09
2	26.13	548 73
3	24.68	518 28
4	32.91	691 11
5	29.02	609 42

The greatest difference, based on the cost of the gold only, amounts to $244.02, or by eliminating the highest, which appears to be somewhat abnormal, the difference becomes $162.33. In other words, the purchaser of 100 ounces of the article containing the smallest per cent. of gold is paying $162.33 for something he is not getting. In this case, as in many others, the cheapest is the most costly.

NOTES AND COMMENTS.

A RIVAL TO CELLULOID.

The British *Journal of Photography* calls attention to the fact that nitrated cellulose has long held the field as the basis of a flexible glass, as celluloid has been called; but there seems a probability that before long Messrs. Cross and Bevan's invention, aceto-cellulose, may be found a formidable rival, for it possesses many advantages over the pyroxylin, which, in combination with camphor, is the main constituent of celluloid. * * * Perhaps the most conspicuous quality of the acetate compared with the nitrate is its non-inflammability—it burns very imperfectly. It differs further from the latter in that it is insoluble in methylic and ethylic alcohols, acetates of amyl and ethyl, acetone and ether, but is soluble in benzoate of ethyl, chloroform, epichlorhydrine, acetic anhydride, glacial acetic acid and nitro-benzine, the solution in the latter becoming a solid, completely transparent jelly. The solution in the other named liquids can be diluted with acetone without precipitation taking place. The

aceto-cellulose resists most reagents in a remarkable manner. Dilute acids and alkaline dyes destroy nitrocellulose; but, with the exception of dilute nitric acid, do not act upon the new substance, in some cases even when boiling. It is probable, too, that, used as a basis for films, it will be possible to dry them quickly by the aid of alcohol in the usual manner, a process quite out of question with celluloid, as any one knows to his sorrow who has tried it. W.

BOOK NOTICES.

Theatres: Their safety from fire and panic, their comfort and healthfulness. By Wm. Paul Gerhard, C.E. (8vo, pp. 110.) Boston: Baker & Gould Company. 1900.

This volume is a collection in book form, with additions, of various articles contributed by the author to the British Fire-Prevention Committee and the *Popular Science Monthly*.

This subject is treated under two heads: (1) Safety from Fire and Panic; (2) Comfort and Sanitation.

The author has given both phases of his theme careful and intelligent consideration, and the book should prove a great help to architects and proprietors of this class of buildings. W.

Practical Methods for Determining Molecular Weights. By Henry Biltz, Privat-Docent at the University in Greifswald. Translated (with the author's sanction) by Harry C. Jones, Associate in Physical Chemistry in Johns Hopkins University, and Stephen H. King, M.D., Harvard University. Easton, Pa.: The Chemical Publishing Company. 1899. 8vo, pp. vi–235. (Price, $2.00.)

In this work, Professor Biltz has collected and arranged in proper sequence all the methods that have been devised for the determination of molecular weights, with full descriptions and illustrations of the various forms of apparatus employed, and the manner of carrying out the experiments.

The references to original sources are so freely given throughout the book as to make it not only a satisfactory guide to the investigator in actual laboratory practice, but also a valuable reference book to the literature of molecular weight determinations.

The work of the translators has been done very satisfactorily. W.

Electric Power Transmission. By Louis Bell, Ph.D. (Second edition, revised and enlarged.) New York: Electrical World and Engineer, Inc. 1899.

Electrical engineers are quite familiar with this excellent treatise, which appeared originally in 1897. The present edition has been carefully revised and enlarged by the addition of a fresh chapter, in which are set forth the recent important advances in the art of power transmission at very high voltage and to long distances, and the recent additions to our knowledge of the theory of high-voltage phenomena. W.

Hand-book of Testing Materials. For the constructor. Part I. Methods, machines and auxiliary apparatus. (In two volumes. Vol. I, text; Vol. II, illustrations.) By Prof. Adolph Martens, Director of the Royal Testing Laboratories at Berlin and Charlottenburg. Authorized translation and additions. By Gus. C. Henning, M.E., Member of the Intern. Association for Testing Materials, etc. 8vo. Cloth. 2 vols. Vol. I, pp. li–622. Vol. II, 1,030 figures. New York: John Wiley & Sons. London: Chapman & Hall, Ltd. 1899. (Price, $7.50.)

The methods of testing materials of construction have probably come in for a greater share of attention during the past decade than any other branch of applied science. With the great advances in the metallurgical arts more especially, and the prodigious increase in consumption in the arts of peace and war, have come more onerous requirements as to the quality of material and more rigid systems of inspection. The world-wide interchange of products of this class and the active competition among manufacturers have made the need of uniformity of methods of testing felt most keenly, and the formation of an active international association for accomplishing this object is evidence that its importance is fully appreciated.

The thorough work of Professor Martens, one of the masters of this branch of applied science, is a most valuable and timely contribution to the subject, and will undoubtedly contribute substantially to the work of establishing uniformity in methods of testing and in giving the engineer a more precise and scientific knowledge of the properties of materials used in the constructive arts.

Part I of Professor Martens' work comprises the consideration of the general properties of materials of construction, testing materials, testing machines and measuring instruments. The text and plates are in separate volumes, and the references to original sources of data are elaborate and complete.

The translator is a well-known engineering expert, fully qualified by training and professional experience to undertake the responsibility of Englishing this important work, and he has done the work most creditably. W.

The Past and Present Conditions of Public Hygiene and State Medicine in the United States. By Samuel W. Abbott, Secretary of the State Board of Health of Massachusetts. (8vo, 103 pp.)

This publication constitutes the nineteenth of a series of monographs on American social economics, issued under the editorial supervision of Prof. Herbert B. Adams (Johns Hopkins University) and Richard Waterman, Jr., in the interest of the Department of Social Economy, for the U. S. Commission to the Paris Exposition of 1900, and is a contribution to this branch of the government exhibit by the commonwealth of Massachusetts.

It is a concise and thorough exposition of the progress which has been attained in the United States in matters pertaining to the public health. W.

The Railway and Engineering Review, of Chicago, has exhibited commendable enterprise in issuing in sumptuous form a "Portrait Souvenir Edition" in honor of the Master Car Builders' and the American Railway Master Mechanics' Associations, which met in convention at Saratoga, N. Y.,

June 18th–23d. The impression is embellished with nearly 400 portraits of the officers and members of the two associations, executed in the best style of the engravers' art, and will prove an interesting souvenir of the occasion. W.

Craft's Tables of Plate and Rivet Values. Thos. H. Craft, 16 Kelton Street, Cleveland, O. (Price, $1.)

These tables of plate and rivet values have been carefully worked out by the compiler for the use of boiler designers, boiler makers, inspectors and engineers, to assist in designing and calculating the efficiency of boiler joints. W.

Architects' Hand-Book on Cements. By Addison H. Clarke. Baltimore: Wm. Wirt Clarke & Son. 1899.

This handy little volume, ninety-six pages, pocket-book size, contains, in condensed form, a considerable collection of facts and data covering the mixing and using of cements adapted specially to meet the wants of the architect and builder. W.

Encyclopédie Scientifique des Aide-Mémoire. Paris: Librairie Gauthier-Villars. Small 8vo, in paper, 2.50 francs; bound, 3 francs.

The following additions to this useful series of technical hand-books have appeared since our last notice:

La Garance et l'Indigo. Par G. F. Jaubert, Directeur de la Revue générale de Chimie pure et appliquée, Docteur ès Sciences, ancien Préparateur de Chimie à l'École Polytechnique.

Produits Aromatiques Artificiels et Naturels. Par G. F. Jaubert.

Les Matières Odorantes Artificielles. Par G. F. Jaubert.

Les Parfums Comestibles. Par G. F. Jaubert.

Recherches des Eaux Potables et Industrielles. Par Henri Boursault, Chimiste à la C^ie^ du Chemin de fer du Nord.

Each of these publications is complete in itself, and the series, as a whole, forms an admirable compendium of the applications of science to the arts and industries. W.

Traction Electrique. Par Eric Gerard, Directeur a l'Institut Electrotechnique Montefiore, etc. Paris: Gauthier-Villars. 1900. (8vo, pp. 136, with illustrations.)

This publication is substantially a reproduction of the course of lectures conducted by the author in the above-named institution, and much of the material contained therein has appeared in the author's "Leçons sur l'Électricité," previously noticed in the *Journal.*

The subject is treated under five heads, as follows: General Considerations on Electric Tramways; The Various Systems of Electric Traction; Making Plans and Specifications for an Electric Traction Project; Electric Railways; Cost of Electric Traction.

Many of the considerations of the author are based upon data gleaned from foreign methods of practice, and the work accordingly should be specially interesting to American engineers. W.